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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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NOTES AND COMMENTS.

Standards for Cast Iron.

Whenever a new steelworks installs a chemical laboratory, the chemist, if he is wise, includes in his equipment a series of steel drillings of known composition. From these he can establish with certainty methods which, under the conditions available, will give accurate results. The importance of the use of standard steel drillings will be realised by ironfoundry chemists by reference to the various Papers read by Mr. C. H. Ridsdale before the Iron and Steel Institute. Some large steel works laboratories put through each day a duplicate standard steel with the samples to be analysed for the elements sulphur and phosphorus, and correct the results of the whole batch according to the percentage yielded by the standard steels.

Whilst some work has been carried out on cast iron, the subject is as yet practically untouched, owing to the large quantities of impurities present when compared with steel and to its less exacting employment.

Research on cast iron is now being undertaken with more zest than has ever been known in this country, one of the objects being to increase the sphere of employment by the production of a more reliable and higher grade alloy.

The data published by the British Cast Iron Research Association will no doubt be checked by the more enterprising of foundrymen, and here will arise the necessity of exact analysis if confirmation and reproduction are to be obtained.

Researches now available indicate that the limits in composition are not so broad as they were formerly imagined to be, and the future may narrow them still more.

The preparation of standard samples of cast iron may in itself reveal much of interest. The phenomenon of segregation may be much greater than is expected. The free carbon, though evenly disseminated throughout the mass in the cast iron, may segregate in the drillings, especially through the vibration of transport. Of the harder varieties, special precautions may have to be taken to avoid contamination with material worn from the drill or milling cutter edges.

Several years ago samples of steels were sent to the chief steel-making countries of the world, and whilst, on the whole, agreement was shown, differences were sufficiently great to admit or preclude use in established specifications.

Now that cast iron is to be brought to finer limits further efforts in this direction could be usefully made, for if cast iron is to be placed on the same scientific basis as steel ingot manufacture, it is essential that its chemical composition should be determined in such a manner as to place it beyond doubt, and the general employment of standard cast irons is the most feasible method of quickly attaining this desirable result.

The basic question of deciding the composition of the series to be made is in itself most difficult, as the experimental chemist will naturally require the impurities to be at a minimum, the Lancashire founders a typical composition for textile castings, the stove-grate manufacturers a high-phosphorus iron, and motor-car manufacturers a "high-test" cast iron. Such a list could be added to almost *ad infinitum*, so complex is this material known as cast iron.

We are aware that many urgent problems are being dealt with by the Research Association, but we cannot imagine one more important than outlined above, as its accomplishment would establish for the industry a means by which work in the foundries could be carried out with that degree of exactitude so necessary for scientific research.

Foundry Congress at Liège.

At this Conference, which opened yesterday at Liège, and will be continued until October 1, the following Papers will be submitted:—(1) "Light Alloys in Foundry," by M. de Fleury; (2) "Costing in the Foundry," by M. Robsy; (3) "Recent Progress in Malleable Iron and the Manufacture of Iron for Malleables," by M. de Herstal; (4) "An Attempt to Standardise Foundry Nomenclature," by M. Lamoureux; (5) "Electrically Manufactured Synthetic Irons in the Foundry," by M. Kelier; (6) "Apprenticeshep and Technical Instruction," by M. Ronceray; (7) "The History and Prospects of Small Convertors with Reference to the Steel Foundry," by M. Devoz; (8) "Scabs, Deep Seated and Subcutaneous Blowholes in Cast Iron," by M. Léonard; (9) "A study on Jarramming Moulding Machines," by M. Grospierre. Additionally, M. Portevin, the well-known metallurgist, has promised one or several interesting communications.

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Silicon in Cast Iron.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Mr. J. E. Fletcher's letter in your issue of September 8, 1921, referring to Professor Rhead's article and the constitution of the iron silicide compound existing in cast iron is of considerable interest.

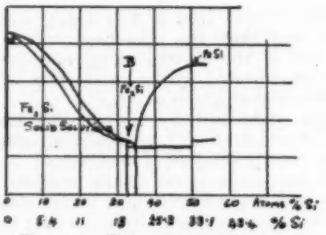

FIG. 1.—GUERTLER & TAMMAN DIAGRAM.

It has generally been considered that this compound exists in cast iron as Fe_2Si, and this view is undoubtedly based on the binary constitutional diagram by Guertler & Tamman. In this diagram, as shown in Fig. 1, the addition of increasing quantities of silicon to pure iron was found to result in a gradual diminution of the freezing temperature till, at a temperature of 1,250 deg. C. and a concentration of 31 atoms per cent. (approximately 18 per cent. by weight), the alloy is considered to solidify as the chemical compound Fe_2Si. In the whole range of alloys up to this concentration of 31 atoms per cent. the silicon is regarded as existing in solid solution as the above chemical compound. Guertler & Tamman's diagram is rather curious at this point, and another interpretation of this point is theoretically admissible. This alternative interpretation has been put forward by Gonterman (J.I.S.I. Vol. 1, 1911), who states that neither interpretation conflicts with the experimental evidence of Guertler & Tamman. This alternative view considers that the point indicating a concentration of 31 atoms per cent. of silicon closely corresponds to the saturated solid solution of the well-authenticated compound FeSi, and that the point B corresponds to the temperature and concentration of the formation of the eutectic of this saturated solid-solution and the chemical compound FeSi. To represent this correctly a slight alteration is necessary in the diagram, and Fig. 2 shows the altered diagram as drawn by Gonterman. The dotted lines in the diagram and the thick lines have been included by Gonterman to indicate the course of the transformations so far as they are reliably known and their probable continuation.

The more recent work of Sanfourche (Revue de Métallurgie, No. 3, May-June, 1919) adds considerably further to the complexity of the problem. The existence of the FeSi compound is fully confirmed by this investigator. With regard to the Fe_2Si compound, Sanfourche appears to rely on the previous work of the other investigators, Guertler & Tamman, for the interpretation of the very slight maximum in the liquidus curves. It should be noted that Sanfourche called attention to the fact that the fusion of the alloy does not take place at a constant temperature, but he finds a solidification range extending over 4 deg. C.

Sanfourche's diagram, which is illustrated in Fig. 3, also shows a break in the curve at 14.29 per cent. corresponding to the composition Fe_3Si, although Sanfourche again is uncertain whether or not this is a true chemical compound or a solution, and certainly more evidence is required to establish its existence as a definite chemical compound.

It should always be remembered that we have experimental evidence of the existence of a definite Ar2 point in the 31 atoms per cent. alloy, and if this is to be believed, it is a very sound reason for considering that this point represents more rather a saturated solid-solution than a chemical compound, and it is mere coincidence that the composition happens to conform to the requirements of a definite chemical compound—a circumstance very frequently encountered.

Mr. Fletcher's calculations from an assumed equation representing a certain chemical reaction are inadmissible. The values obtained by Wust & Petersen of eutectic percentage of carbon in the presence of varying amounts of silicon represent the extent of mutual solubility, under equilibrium conditions, of the silicon compound and the iron carbon compound at the eutectic temperature. The same values for carbon percentage would, of course, be obtained if the pure iron-silicon compound were added direct to the pure iron-carbon eutectic, and no question of chemical reaction arises. This calculation gives no proof either way as to the existence of the chemical compound.

Table showing the Calculated Carbon per centages assuming the existence of FeSi, Fe_2Si and Fe_3Si.

Si contents per centage (Wust.)	Per-centage Carbon (Wust.)	Equiva-lent per cent-age FeSi	Per-centage 4.3 Carbon Eutectic	Equiva-lent per-centage Carbon,	Equiva-lent per-centage Fe_3Si	Per-centage 4.3 Carbon Eutectic.	Equiva-lent per-centage Carbon	Equiva-lent per-centage Fe_2Si	Per-centage 4.3 Carbon Eutectic.	Equiva-lent per-centage Carbon.
0.13	4.29	0.38	99.62	4.29	0.64	99.36	4.26	0.89	99.11	4.25
0.21	4.23	0.62	99.38	4.27	1.04	98.96	4.25	1.45	98.55	4.24
0.41	4.11	1.21	98.78	4.25	2.03	97.97	4.20	2.82	97.18	4.18
0.66	4.05	1.94	98.06	4.25	3.26	96.74	4.12	4.55	95.45	4.10
1.14	3.96	3.36	96.64	4.16	5.63	94.37	4.06	7.85	92.15	3.96
1.41	3.88	4.15	95.85	4.11	6.98	93.02	4.00	9.70	90.30	3.90
2.07	3.79	6.10	93.90	4.04	10.27	89.73	3.85	14.22	85.78	3.68
2.68	3.56	7.90	92.10	3.96	13.26	86.74	3.73	18.42	81.58	3.50
3.25	3.46	9.58	90.42	3.89	16.03	83.97	3.60	22.38	77.62	3.33
3.69	3.37	10.88	89.12	3.85	18.24	81.76	3.51	25.48	74.52	3.22
3.96	3.24	11.68	88.32	3.80	19.61	80.39	3.46	27.26	72.74	3.12
4.86	3.08	14.37	85.63	3.68	24.10	75.90	3.26	32.62	67.38	3.80
5.06	2.86	14.92	85.08	3.66	25.00	75.00	3.23	35.79	64.21	2.76

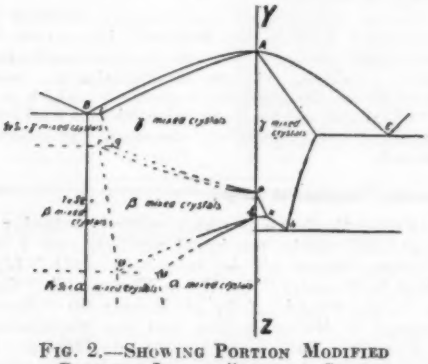

FIG. 2.—SHOWING PORTION MODIFIED BINARY IRON SILICON SYSTEM (*Gonterman*, J.I.S.I., Vol. I. 1911.)

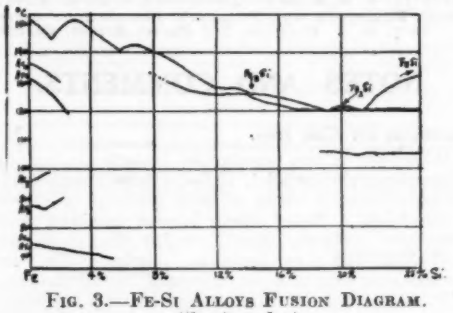

FIG. 3.—FE-SI ALLOYS FUSION DIAGRAM. (*Sanfourche.*)

Mr. Fletcher states that his own examination of the alloys quenched from the molten state showed them to consist "of a ground mass of 4.3 per cent. carbon eutectic containing dendrites of Fe_2Si." I submit above a series of calculations of the carbon percentages in the Wust & Petersen series of alloys based on this observation that the alloys consist of Fe_2Si plus the 4.3 per cent. carbon eutectic. I have also calculated the results on the assumption that the compound is FeSi and also Fe_2Si, which might be conceivably possible from Sanfourche's work. It will be seen that Fe_2Si more nearly coincides with Wust & Petersen's actual figures. Calculations of this nature, presupposing the existence of compounds are, of course, not admissible, and Mr. Fletcher's own statement that the *compound* existed as dendrites confirms my own view, which seems to be the only one possible in the light of present knowledge, that the compound should be regarded as FeSi, and it is a solution of this compound, together with carbide of iron and iron, which is first deposited on cooling, and that this solution enters into the constitution of the binary eutectic in the ternary alloys of iron-carbon and silicon.—Yours, etc.,

J. E. HURST.

3, Sandilands,
Troon.

The Foundrymen's Conference.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—The Annual Conference is over, and it is not out of place to refer to one or two of its glaring failures. These Conferences are supposed to be held (1) for the exchange of opinions by the members upon matters affecting their profession or industry; (2) for social intercourse.

Take the first point: members were asked this year to make long journeys to discuss two Papers only, and so scarce apparently are our own foundry experts that one Paper had to be sent over from America. It is admitted that both Papers were most valuable contributions and would create most instructive discussions, but one whole morning was wasted in reading a long Paper (although it had previously been circulated), and the total discussion at the Conference upon the two Papers was therefore limited to 1¾ hours only. Members took long journeys to speak and give without doubt valuable information, but were unable to do so by sheer waste of time. The whole thing is a perfect farce, when you see how other Institutions manage their Conferences, and unless future meetings are better managed only those members who want a joy-ride will attend.

Now take the social side: pleasurable arrangements, of course, were made for the members, but as a special request had been made that members should take their lady friends, it was astonishing to find that they were not allowed to attend the two functions and were left to wander about without the least possible attempt made for their pleasure. It is to be hoped that Birmingham will try to do better, or otherwise it will be difficult to induce them to attend any future Conferences. —Yours, etc.,

DACIE.

September 19, 1921.

Hoisting Speed of a Crane.—The hoisting speed of a crane depends on the hoisting height, the nature of the load, and the service. According to an American writer, the following speeds are suggestive of existing practice :—

Type of crane.	Capacity (tons).	Hoisting speed per min.
Hand-operated ..	1 to 5	1 ft.
Stand-by	—	10 to 25 ft.
Ladle crane ..	100 to 150	10 to 15 ft.
Mill service ..	5 to 15	25 to 60 ft.
Mill service ..	20 to 50	15 to 30 ft.
Foundry	5	40 ft.
Foundry	10 and above.	12 to 25 ft.
Auxiliary hoists ..	—	25 to 60 ft.
Skull cracker ..	5 to 15	80 to 120 ft.
Ore bridge ..	5 to 10	200 to 600 ft.

The Fallacy of Weighing Patterns.

By F. C. EDWARDS.

The practice of weighing a pattern in order to arrive at the weight of the casting is as common as it is misleading. The practice is not, moreover, confined to the foundry, but is often resorted to by the drafting room—where it is, perhaps, less excusable. The tables that one finds in various text-books giving ratios between the weights of certain kinds of wood and the different metals also lend authority to this practice. Nevertheless, a little consideration of the facts will show that in very few cases can even an approximate reliable estimate be obtained by this method; in some cases, indeed, it is altogether out of the question, and, if used, may result in a costly miscalculation.

All woodworkers know that the weight of a given kind of wood is materially affected by two factors, viz., the moisture it contains and the nature of the grain. This means that a piece of wet or strong-grained yellow pine may have the same weight as a piece of hard wood—mahogany, for instance—of equal dimensions. Further, there are several species of mahogany in common use with varying degrees of hardness—and hardness implies weight in this case.

There may be a greater difference between the relative weights of the softest and the hardest kinds than is often found to exist between strong-grained yellow pine and light mahogany.

It may, of course, be retorted that the relative weights given in the tables specifically refer to "seasoned woods," but how is one to determine whether a finished and, may be, nicely-varnished pattern is composed of a certain kind of wood, brought to the particular degree of seasoning on which the ratios in the tables are based?

The absurdity of the practice is even more pronounced where a pattern is "boxed up," *i.e.*, constructed so as to leave large hollow spaces, or where it is cored out in the casting to any appreciable extent. In the former case, since parts of the pattern may be hollow which would be solid in the casting, it might conceivably be found—when too late—that the casting required, say, 30 per cent. more metal to run it than the calculation allowed—according to the given ratio between the weight of the wood in the pattern and the actual metal requirement. And in the latter case, *i.e.*, where a dry sand core in the casting takes the place of the core print, the casting would obviously weigh—to that extent—lighter than calculated.

Occasionally, of course, an approximate calculation is really arrived at, and this—like an occasional stroke of luck in gambling—is where the danger lies: it engenders a certain amount of faith in a method, the soundness of which cannot be substantiated either by reasoning or long experience.

MR. J. CHURCHWARD, chief mechanical engineer of the Great Western Railway, is retiring shortly.

Census of American Blast Furnaces.—Preliminary census figures, published by the "Iron Age," for 1919, based upon the returns from 195 blast-furnace establishments, show products valued at $794,466,600. In addition, pig-iron to the value of $6,595,800 was produced by five establishments included under other classified industries, making a total of 200 establishments, and $801,062,300 in products. At the census of 1914 there were 160 blast-furnace establishments, with products valued at $317,654,000. The 1914 figures include blast-furnace ferro-alloys, spiegeleisen, ferro-manganese, etc. (329,580 tons), which are not included in the pig-iron figures for 1919, hence the actual growth is somewhat greater than above indicated. The producers consumed in their steel furnaces, etc., 71 per cent. of the production in 1919 and 66.6 per cent. in 1914. Consumption of iron ore in 1919 was reported by the U.S. Census Bureau at 56,333,358 tons, costing $310,981,100, and in 1914, 43,326,817 tons, costing $150,855,700. Less than 1 per cent. of the tonnage was foreign ore in 1919, as compared with 4.1 per cent. in 1914. These results show 4,133 lbs. of ore per ton of pig-iron in 1919, and 4,180 lbs. in 1914. Coke and coal to the amount of 34,654,421 net tons were reported consumed in 1919, being 2,293 lbs. per ton of product. In 1914, the 26,982,293 tons consumed represented 2,347 lbs. per ton of product.

XUM

Oil Sand Cores.

By F. A. K.

From time to time foundrymen have introduced to them new core oils, for use with sharp sands, better results being promised, associated with reduced venting and ironing. Some of the photographs produced are very attractive, showing cores both delicate and intricate, and in all cases increased economy is promised.

Many founders are using these oils with success for cores which, in some cases, would not be possible, made with ordinary core sand with a clay bond, and in others would take much longer to make, while the resulting core would not be so strong.

The majority of the successful users of core oil do not owe as much to published information as to their own experiments with different mixtures, control of core-oven temperature, method of mixing, skilled coremakers, and systematic working.

Pit sand, river sand or sea sand, and, in some cases, burnt sand, is used—a suitable sand, consisting of rounded grains, with a minimum of dust or clay, and in the case of sea sand it should, if at all possible, be obtained without particles of broken sea shells. A pocket lense will reveal shell in some sands in considerable quantity, although invisible to the naked eye.

With shell present more oil is necessary, and when the core becomes in contact with the hot metal, the shell, consisting of calcium carbonate, is decomposed and evolves 44 per cent. of its weight as carbon dioxide. Additionally there is the excess of oil absorbed by it, and which plays no part in binding together the sand grains. The result is that it often happens that the vent outlets are overtaxed, and the gases escape through the face of the core into the mould, resulting in a blown casting.

For cores that have to stand for some time in a green sand mould, sharp sand from a pit is preferable to sea sand, the latter contain salts (chiefly common salt), and these absorb water. The result is that after being in a closed mould for a hour or more cores made with this sand are more or less covered with dew, consequently blowing is to be expected.

It is important that only just sufficient oil be added to the sand to make the core suitable for the particular casting. Any excess must either be baked out, occupying more time, or must be driven out during casting. This cannot be by any means considered correct, even if the gas does escape by the proper channels. The oil must be added to the dry sand, which must be cold and thoroughly mixed, before any water is added to the sand. If the sand is used without a preliminary drying, the ideal condition of each sand grain being coated with oil is more difficult to obtain, and an irregular core results. Further, the quantity of water to be added must not be guessed, as it leads to poor results in baking and withdrawal of the core from the corebox prior to baking.

In the opinion of the writer the quantity of water to be added is as important as the quantity of oil, as the water during evaporation helps to carry off the volatile constituents of the oil which must be removed during baking, leaving the remainder to fulfil its proper function as a bond, until the higher temperature of the casting eventually decomposes it, to escape as gas by the prints and leave the sand easy of removal during dressing.

With too little water some parts of the core become dry and friable, principally those in contact with coreplate. The upper parts become hard and non-porous at the surface, causing an excess of oil to be retained, this excess blocking the pores and producing a compact mass difficult to rub with a file. Such a condition causes blowing in cores provided with only small prints for vent outlets. Such cores are very apt to soften and warp in the mould when the metal comes in contact with them, and give off a tremendous amount of gas at the vents, burning with a large white flame, which deposits clouds of soot. With a correctly-baked core the flame, for a few seconds, is blue, resembling the Bunsen flame, and later develops into a white flame.

The dryness and friable character near the plate creates the impression that there is a deficiency in oil, and more is added, which not only increases the costs, but, unless the cores are well baked blown castings will be produced. Even with the same mixture it will be found that much depends upon the coremaker. The writer's practice is to avoid ramming as much as possible, and he considers that much of the venting by means of wax vents could be dispensed with if hard ramming were avoided. In the case of intricate jacket cores there should be very little difference in the weight of core observable, as this means either more sand or oil has been used, and therefore less pore-space. Hence greater tendency to blow.

The temperature of the core oven is important, as the result of too low a temperature has a similar effect to a deficiency of water.

Time also of baking is important, as very little time after the core is baked suffices to burn it, after which it cannot be handled and crumbles to powder.

From experience, the following oil-sand mixture is recommended as being especially suitable for water-jacket cores for four cylinders (monoblock) :—Core oil, 1 pint; core gum, 1 tablespoonful; dry sea sand, 18 pints; water, 5 pints.

The procedure to be adopted is to mix dry sand and core gum. Add the core oil and mix thoroughly *by hand*. The mixture is then passed through a $\frac{1}{4}$-in. mesh riddle and the water added. The whole is then well mixed and riddled again, after which it is ready for use.

Coremaking.—The sand mixture is lightly filled into the core-boxes, wires and wax vents being laid in where necessary. When the box is full pressing lightly with the fingers and strickling off without sleeking with tools is all that is necessary. After covering with *thin* paper and packing with sand, which should not be too damp, the box is turned over, lightly rapped and the core withdrawn, but if the exposed surface is flat, packing sand can be eliminated. Any broken parts must be replaced and put aside until a batch is ready. It is advised to moisten delicate portions of the core with few drops of oil and to put them in a very hot oven and leave for an hour. Then take one of the cores and ascertain if it yields to pressure of the edge of a cleaner. If firm, baking is complete, and the whole batch can be removed. If soft and yielding to the cleaner, the trial core is returned to the oven and left for fifteen minutes and retested.

These cores are generally ready at the end of an hour's baking, but with a coke fire variations in temperature will occur, and the advantage of gas-fired furnaces is obvious.

A coating of blacking should be given when the cores are cool enough, in order to avoid the blacking boiling-off the core.

Pyrometers are too expensive for some foundries, but a crude apparatus may be formed by fixing one end of an inch bar of iron on a gudgeon in the stove wall, the other end fitting on a pin on the short arm of a bell crank lever, the longer arm traversing a quadrant. The expansion of the bar will be multiplied by the long arm of lever and its position noted for repetition, when the temperature of the stove or oven is suitable. From the expansion of the bar of known length and coefficient of linear expansion, a simple calculation will give the approximate temperature.

STRENGTH OF STEEL AT HIGH TEMPERATURES.—A Paper, "Comparative Tests of Steels at High Temperatures," by R. S. MacPherran, chemist, Allis-Chalmers Manufacturing Company, West Allis, Wis., was presented at the annual meeting of the American Society for Testing Materials. The tests recorded were made to ascertain the comparative properties of various steels at high temperatures to obtain information as to the best material for use under operating conditions of 315 to 535 deg. C. Carbon and alloy steels, both rolled and forged, were used. The Paper gives in detail the apparatus employed for heating test pieces already placed on the testing machine. The tests do not warrant any definite conclusions, says the author, but they throw light on the subject and indicate that further consideration should be given to the properties of various alloy and carbon steels at high temperatures.—"Iron Age" abstract.

Institution of British Foundrymen.

Annual Conference at Blackpool.

Second Day's Proceedings—(*continued*).

Some Perplexing Foundry Problems.

Mr. J. Shaw (Sheffield) read his Paper under this title. (See p. 257).

The PRESIDENT said this was another illustration of the necessity for the Cast Iron Research Association, and he hoped the proceedings that morning would help them to get at something tangible and clear away difficulties. If they were difficulties to Mr. Shaw what must they be to others who were not so conversant with the subject?

The Role of Oxygen and Sulphur in Cast Iron.

MR. H. P. MASON (Barrow-in-Furness) said the thanks of the founders of the country are due to Mr. Shaw for once again introducing the question of oxygen in cast iron, and he would confine his remarks to this subject which abounds in apparent contradictions.

When it is realised by all that oxygen has to be reckoned with as a potent cause of foundry trouble we shall doubtless make some progress. The element has been proved to be present in small amounts in cold cast iron, but we shall not possess very definite working data until we devise some method of determining its quantitative state of existence in the molten metal. In the absence of such data we must bring our practical experience to bear on the subject, and be guided by the various phenomena presented to us.

Silicon and manganese as constituents of cast iron are generally oxidised under cupola conditions; in fact, the oxidation of these elements is an essential part of cupola practice, but when working under correct cupola conditions and with a suitable mixture and slag, the oxygen is sufficiently removed from the metal without it leaving any very pronounced ill-effects.

Cast iron is occasionally very badly oxidised in the cupola. Some years ago the speaker investigated the cause of a run of bad castings. The foundry at that time was attempting to keep up production with a smaller cupola than it had been accustomed to use. This cupola was fitted with two rows of tuyeres and receiver, the air being supplied by a Root's blower which had been installed for a considerably larger furnace. The mixture being melted was intended for cylinders and analysed about 1.25 per cent. silicon and 0.8 per cent. manganese. One of the constituents of the mixture was an iron containing about 1 per cent. silicon and 2 per cent. manganese. As tapped, the metal was hot, but lifeless, and the castings were beautifully besprinkled with small holes on the cope side—many of them containing slag in addition, even although they had been cast through plug gates into dry sand moulds. The pig-iron was being blamed for the trouble, and was said to be "sulphury" and "dirty." Sulphur was supposed to be the seat of the trouble. The metal was not at all high in sulphur; in fact, it was low (about .05 per cent.), but it was judged to be so from the fact that as it was run from the cupola there was a very strong smell of sulphur dioxide, which was decidedly abnormal, and the charge was being oxidised, as was evidenced by the state of the metal and also from the volume of brownish-red fumes being emitted from the cupola stack. The metal was dirty, for on standing in the ladle slag formed and concentrated in patches on the surface of the metal, and as this was removed more was formed which, on being removed and analysed, was found to consist chiefly of manganous silicate ($MnO\ SiO_2$) with about 10 per cent. of ferrous silicate, about 1 per cent. of manganous sulphide and no lime. Powdered 80 per cent. ferro-manganese was being added to the ladle to remove the sulphur, but it was not a success in the removal of the trouble. The addition of 0.02 per cent. of aluminium was, however, effective. The chill was reduced about 50 per cent., the fluidity was greatly increased, and the metal cast quite sound with fine graphite and good mesh structure. An additon of 0.05 per cent. of sulphur, added to the ladle in the form of ferrous sulphide, was also effective in the production of sound castings.

That the smell of sulphur dioxide from the metal running from the cupola was due to oxidation by the atmosphere of the manganese sulphide rising to the surface might be dismissed, as on the same blow a soft mixture containing practically the same amounts of sulphur and manganese, but about 2 per cent. of silicon was run without any such indications, and the speaker's opinion was that it was due to the combustion of a volatile sulphur gas which the metal could not hold at the reduced pressure outside the cupola. Carbide of manganese is very easily oxidised. In fact, mixed crystals containing 1 per cent. manganese are oxidised by pure carbon monoxide at a temperature as low as 850 deg. C.

Suppose, however, that it is the iron and not the manganese which is oxidised. In the presence of manganese any ferrous oxide formed will be reduced according to the exothermic equation

$$Mn + FeO = Fe + MnO + 25.2 \text{ calories,}$$

or, in the presence of silicon, according to the equation,

$$Si + 2FeO = 2Fe + SiO_2 + 48.6 \text{ calories.}$$

So it may be assumed with some confidence that in the presence of fairly large quantities of manganese and silicon, ferrous oxide cannot exist in the iron, and any which has been formed and reduced by manganese in addition to any oxidised manganese will exist in the metal as manganous oxide, pending its removal to the slag. The existence of manganous oxide would account for the inability of ferro-manganese to remove it. In the manufacture of cupola semi steel under conditions of sympathetic blast and an acid slag, the silicon contents are practically not affected, and no correction for loss need be made. Manganese is, however, oxidised, and if a charge is melted consisting of 100 per cent. steel the percentage of silicon actually rises. For example, a steel containing C 0.53, Si 0.14, S 0.056, P 0.038, Mn 0.79, gave a metal showing the following analysis: C 2.93, Si 0.25, S 0.12, P 0.046, Mn 0.21. Some of the manganese has been oxidised at the expense of silica according to the equation,

$$SiO_2 + 2Mn = 2MnO + Si + 1.8 \text{ calories.}$$

This equation might under suitable conditions be reversed as in the bessemerising of a suitable iron, but the reaction which really matters is:—

$$MnO + SiO_2 = MnOSiO_2 + 5.4 \text{ calories.}$$

In the absence of silica this cannot take place, and after the cupola slag and the refractories of the ladle have functioned, manganous oxide is left in the metal to raise its melting point, reduce its viscosity and produce slag and blowholes in the mould.

This is one side of the question of oxidation when dealing with easily oxidised high-manganese low-silicon iron.

On the other hand, *post mortems* conducted by the speaker on castings scrapped through no fault of their own, which have been made from high silicon iron, through which air has been blown to bessemerise the metal, and they have been excellent in every respect. In this case it is quite feasible that the manganous oxide is reduced by the silicon, of which about 1.5 has been left in the metal.

Oxidation of the metal, in cases where free oxide is not removed, does undoubtedly, through its action on the freezing point, close the metal and result in the production of fine graphite, but equal results can be obtained by metal in which oxygen is at a minimum, provided that the ratio of silicon to carbon saturation is correct without the same risk of wasters.

The concrete case of oxidation mentioned is of a wide application, for with some cupolas it is very difficult practice to melt low silicon mixtures without oxidation unless the manganese be kept below 0.5 per cent.

There is, however, another phase of the question, and that is the effect of oxygen in the production of coarse graphite.

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During the war large quantities of black metal castings were made, which had to meet a crushing-test specification. If the metal was melted very hot the specification was easily met, but if, on the other hand, the temperature was low, although on chilling the molten metal the carbon was found to be in the combined form, the castings made from the sluggish metal had the graphite existing in very much larger flakes, with an absence of mesh structure, and the test could not be obtained.

The addition of a small amount of aluminium to such metal quite altered the structure, reduced the size of the graphite, raised the crushing strength about 10 tons to the sq. in., and slightly accentuated the chill.

The closing of the grain of the metal by aluminium was referred to by Mr. J. S. G. Primrose in a Paper read at the Glasgow Convention in 1910, where it is illustrated by two very clear and convincing photomicrographs.

Brands of pig-iron of practically similar composition so far as C, Si, S P and Mn are concerned, vary considerably in structure, and these differences may be traced to small amounts of deoxidisers, such as titanium or vanadium, and abnormal irons, such as those "over grey," can be normalised by deoxidisers.

These examples apparently contradict the statement that oxygen closes the grain of the metal, but it is quite possible that it exists in another form and functions differently.

At the autumn meeting of the Iron and Steel Institute last year, Messrs. Honda and Murakami of the Tohoku University, Japan, presented a Paper on the graphitisation of iron-carbon alloys. These gentlemen experimented on a white iron containing very little silicon (0.06 per cent.), and their conclusions were that in pure iron-carbon alloys graphitisation is due to the decomposition of the cement solidified during cooling from the melt, which decomposition is produced by a catalytic action of carbon monoxide or dioxide.

It is in accordance with a recognised law that the solubility of gases in molten metal decreases with the rise of temperature. When the metal was raised to a temperature of 1,200 deg. C. they found graphitisation. At 1,300 deg. C. the degree diminished, and on raising to 1,400 deg. C. no graphite was formed on cooling. They found that if they passed air through the melt or mixed iron oxide in it, graphite was formed more readily. Hydrogen or nitrogen were proved to be inert. Their researches are not completed, for they are now experimenting on the effect of silicon in the presence of oxygen, and we look for their next Paper with more than usual interest.

The oxygen question, or rather the oxygen and sulphur question—for sulphur is by no means a sleeping partner—is one which affects everyone connected with the casting of ferrous materials. The factors are so numerous and the results so far reaching, that it is undoubtedly the one question which should demand attention at the hands of the Research Association.

Inherent Qualities in Pig-Iron.

MR. H. J. YOUNG (Wallsend-on-Tyne) said Mr. Shaw suggested the presence of some inherent properties in pig-irons apart from their composition. He hoped all foundrymen would try to realise what that meant. Makers and sellers of pig-iron would support the theory, and it could not be proved or disproved. The composition might be anything, but the maker could say: "There is the inherent quality," and he could not be controverted. It was a matter for the scientist to deal with rather than for the practical foundryman. The British Cast Iron Research Association was in a better position to investigate the matter than the Institution, and it would take a great deal of research work to prove it. He knew that some men held these opinions, but most of them were sellers of pig-iron, and it was a little difficult to know whether in what they said they were influenced by their pockets or by their experience.

He would tell the members something about his own experiments. It was his work to look after two foundries which were a good many miles apart, and the pig-iron used in one was not the same as the pig-iron used in the other. That made it more important that he should be able to see whether iron of similar composition would stand the same tests. He had investigated this, and his results had been tabulated, and some of them bore a definite relation to the subject of discussion. Had any member ever wondered whether the analyses given were correct? As a chemist he could tell them that of all the analyses of metal alloys that of cast iron was the most difficult; he would not trust any ordinary analyses of cast iron, not even from his own laboratory. A sample regarded as important was tested five or six times by different operators, and even then the results were not always convincing. Consequently they might take it from him that when a Paper was written or a statement made about the result of analyses, a great amount of proof of its correctness was needed. Many laboratories considered their work was correct because they had never tried to prove that it was correct. It was often very difficult to prove a thing was correct. Take out one figure from Molesworth's Text Book and try to prove it. They might find a year's work in front of them. It was the same with the analyses of cast iron. He knew of certain particularly high sulphur samples that were very difficult to analyse; every method produced a different result. A great deal would have to be done before they could say that the analysis of cast iron was absolutely correct.

Cast iron contained in solution, in combination, or in suspension, carbon, silicon, phosphorus, sulphur manganese. These ingredients were combined with each other or with the iron itself and also as oxides. Then there were such things as copper arsenic, nickel and titanium, and finally slags and gases. Could a man get up and affirm that his iron had got inherent qualities before he proved what amounts of those various things were contained in the iron? It was known that all alloys were greatly affected by three things: in the first place by very minute amounts of certain impurities or ingredients, secondly by the conditions and temperature of pouring, thirdly by slag inclusions. His experience was that cast iron was not different from the alloys in the way it was affected by those three factors, but he had seen very little done to deal with them. In fact, very little work had been done on cast iron in this country or abroad, and that was why he asked earlier in the morning that they should try to find out more about the cupola before going on to another process.

The differences between test bars of similar composition were often ascribed to the inherent quality of the pig-iron, but the pig-iron was the same if it came from the same ladle; and how many foundrymen would like to say that they could take two test bars from the same ladle and get the same result? There were about fifteen factors that affected test bars, cast in the same way. Many of these factors were differences in the pouring and the moulding. The moulder did not pour it out to make a test bar, which was the most difficult casting in the whole foundry. Then it was quite a difficult thing to machine. Cast iron had a core, and the slightest inaccuracy in machining would put that core out of the centre, and they did not know how that affected it when it came to the testing machine. All these conditions were very difficult to control; in fact, he had never succeeded in controlling the whole of them at once, but the point was that the more control the foundrymen had over them the more the results of the test bars would agree. He had been speaking, of course, of test bars cast from the same ladle. When they came to test the metal from two ladles they got into other difficulties, because it brought in the analyses. He had analysed many hundreds of consignments of pig-iron, and had not come across two that were alike, nor had he found one consignment that was the same throughout. Would any maker of pig-iron guarantee his ultimate analysis? It was said to be strong or close grained or tough, etc., but none would guarantee that the analyses would be the same all through, even one consignment. If the inherent quality existed it must be independent of the composition. Dr. Stead claimed to know of a hot blast pig-iron that was put on the market as cold blast; anybody knew what it really was, but it was perfectly successful. When a man of Dr. Stead's calibre said a thing like that it was worth thinking about. At that time he (the speaker) started work everybody in the district thought Scotch iron

was a wonderful thing, and there were a great many foundrymen who believed in certain local brands of iron. He met one man who said if he had to use A iron he would close his foundry, he must use B iron; but he (Mr. Young) happened to know another man who said exactly the opposite. As the result of hard thinking and a few years' work, he was now in the position of being able to use any pig-iron that came along. He analysed it, and if he found it was not good value for the money he did not buy any more. For some years they had no Scotch iron, in other years they used it, and neither in the laboratory, nor in the works, nor in service had he been able to detect any difference whatsoever so long as the composition was under control. He had a perfectly open mind about the matter. If Scotch iron could be shown to be better he would be glad to use it, but he could find no difference

These four points, he felt, disposed to some extent of the question of the inherent properties of pig-iron. It was very difficult to produce a sample of a consignment which had an inherent quality with which it differed from others, and which could not be explained by analyses. He had not come across one himself.

With regard to the standardisation of test bars he would suggest that whatever was done by the Institution their action should be limited by their knowledge. It seemed advisable that all specifications giving the machined-size of the bar should also give its size as cast; indeed, those two sizes might be standardised if only to put an end to the complete lack of all attempts at standardisation among engineers and foundrymen in general. For bars cast from the ladle the American specification was very good, but it did not solve the main difficulties connected with the bar in its relation to the main casting. Tensile bars varied tremendously, largely because moulders and mechanics did not appreciate the very great difficulties that arose in the making of a correct test bar.

If anything was produced different from others it was called a freak, and the term even appeared in Mr. Shaw's Paper. A lot of iron produced castings which were not expected, and it was called a freak iron. If a few of these freaks were followed up and cultivated it would probably appear in after years that the differences were due to definite qualities of the iron. They were different types of iron, and were quite explainable when correctly understood, but at present the knowledge concerning them was very small.

MR. YOUNG, continuing, said he did not agree that the conditions mentioned by Mr. Shaw were stabilised. Personally he had never been able to stabilise them. Pig-iron might be covered with sand or it might have a nice, clean surface. How were they to stabilise cupola practice to allow for one not having the same surface as the other? One would require a higher melting temperature, another would absorb carbon more quickly. If anything was unstabilised the passage of the metal through a cupola was. He should very much like to see the subject further studied. Another thing that Mr. Shaw also referred to was the stabilisation of the pouring temperature. He himself had not yet reached that point. It was exceedingly difficult to know the pouring temperature. There were alloys in which the rate of pouring had a great effect upon the results, and one could not be certain that the rate of pouring was the same. Other things would have to be brought in before it could be said that the conditions had been stabilised.

The points which Mr. Shaw had brought forward did not in any way enter into what he (Mr. Young) had been saying, but he had not stabilised all those things, and he was very dissatisfied with what he had done. If any man had stabilised his cupola practice he should very much like to work under him for a while so that he might do likewise; but how many of them could use the same mixture day after day and get precisely the same results? How many tried to make the same mixtures and got the same results? If a foundryman took five different pig-irons and made a mixture yielding a certain analysis how many of them could take five other pig-irons, mix them and get the same analysis?

He was sorry Mr. Shaw brought in the Hailstone and Cook Paper, because their criticism had nothing to do with that Paper.

MR. R. BUCHANAN (Past-President) said their knowledge must always remain incomplete, but if they did not work with such knowledge as they thought they had, how were they going to work? According to Mr. Young, the chemist practically never analysed correctly. How far then did this criticism of pig-iron or castings carry them? Mr. Young argued that the methods most chemists used were incomplete, and in most cases incorrect; the machine men did not machine correctly, the cupola men did not melt correctly, the moulder did not mould correctly. Where were they then when all the people had contributed their various inaccuracies? It was better to begin anew and start upon some definite basis, which had yet to be found. All that remained at present was to continue working with the intelligence they had, although inaccurate to some degree, and was likely to remain so.

THE AUTHOR'S REPLY.

MR. SHAW, in his reply, stated he was sorry time had not allowed all those who wished to take part in the discussion to do so, but if they would forward their notes to the Secretary it would add to the interest when published. There was one point he wished to make clear, namely, that in the series of tests mentioned where the larger bar gave the lower test of 14 tons, it must not be thought that 17 tons could not be obtained on a $\frac{3}{8}$-in. dia. bar with a suitable mixture.

Coming to the written and oral contributions, he thought it would be best to sum up the evidence, pro and con, on the points raised at the end of the Paper.

No. 1.—After reading the conclusions reached at the end of the two latest investigations on the Ledebur and other methods of estimating oxygen in cast iron, one can only conclude that until some simple and correct method is devised the whole question is one of speculation. At the same time the results published by Johnson, Elliott, Moldenke, Pickard, etc., leave no doubt that oxygen can be present, in some form, in cast iron containing even up to 2 per cent. silicon. The fact that Dr. Howe accepts Johnson's conclusions adds weight. That the Americans have established special laboratories solely for the delicate estimation of oxygen in iron and steel prove that there its importance is recognised.

As to its benefits or otherwise—here again there is a lack of definite proof. Under certain conditions there is fairly general agreement that inclusions are harmful, that this metal freezes at a higher temperature, that it is sluggish and deepens the chill. Two speakers suggest that oxygen may occur in two forms, one of which is harmful, the other beneficial, but offer no proof. On the other hand, Johnson's results have never been disproved, and Moldenke's and Diller's statements only prove that few grey-iron foundries have a converter, and do not think the advantages to be gained by using Johnson's patent worth the extra cost.

No. 2.—We are here on more sure ground. Many experienced foundrymen and most blast-furnace managers will confirm the statement, that, due purely to furnace conditions, irons do vary in their physical properties even when of the same chemical analysis. This, with the same ores and from the same furnace. Mr. Young speaks of his luck with regard to an iron from a particular furnace. How A swore by it, while B thought it bad. May I suggest that instead of being a proof against the point at issue, the contrary is the case. That A's iron had been sent while the furnace was working normally, while B's first consignment might have been an "off" iron, hence his dissatisfaction. Was Mr. Young's luck in, or his discernment out? Or, take the investigation by Cook and Hailstone; here we know the various irons were carefully analysed and numbered. The cupola conditions were under full control, giving a regular temperature to the metal; the test bars were of the same size and moulded in the same way, giving the same cooling effect. In short, every factor was stabilised as near as possible under works conditions. The fact that the analysis from the resultant test bars came out approximately as calculated is proof that the conditions were as above. How was it then, when using, say, irons Nos. 1, 2, and 3 in certain proportions a test bar with the desired analysis is obtained giving a 17-tons tensile and a network structure? If irons,

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say 1, 4 and 5, were used in proper proportions to obtain the same analysis, the test was only about 14 tons and no network structure, yet the only variant as far as we know was the physical properties of the pig-iron.

Prof. Turner complains of the lack of "interpretation" on the part of the foundrymen. We suggest that if the blast furnaces followed the lines of the Phœnix and other German furnaces, who not only made the usual routine analysis, but also tagged those casts where irregular furnace working took place, some of the need for this interpretation would be gone. Can he, or any one, by examining a laboratory book giving the stocks of pig-iron in the yard, with their analysis, ensure a mixture that will give one a test bar of 17 tons, and the network structure, or must we wait until the £1,000 casting is poured before the result of the test will be known? Joseph would not have received the same reception from Pharaoh if he had left his interpretation till after the end of the lean years. Whilst the Americans do mix their irons by analysis, when it comes to special and strong work, no country is so suspicious of new brands of iron. Diller's remarks on this subject bear this out; or, again, the makers of small chilled wheels cannot be induced to use coke iron of identical analysis to their C.B. charcoal iron.

We have emphasised this point because many foundrymen, when chemical analysis is mentioned, think only of the mixture of the ordinary constituents C, Si, S, Mn and P in certain proportion to give certain results. They either forget or else do not know that at times, due purely to irregular furnace conditions, different physical results are obtained. That remelting these irons in a cupola, either from lack of temperature or other causes, does not restore these irons to a normal condition.

No. 3.—The majority of the evidence is in favour of this point. We may take it for granted that customers will always want a specification and test bars. The latter at least proves that they receive a metal that gives a certain test under certain standard conditions. It would eliminate the need for calculation to compare the various size bars now in use. This standard bar (or bars) would also be invaluable in the works as a check on foundry working and mixtures, and also as a comparison with other works. Granting the above, who are so fitted to draw up a provisional specification and tests as the 1,700 members of this Institution, who have to comply with its conditions, and who are so familiar with the anomalies of some of the present specifications and tests? If this Institution were to draw up a provisional specification for the various types of casting, submit this, say, to the "Mechanical or Civil Engineers" for consideration, the resultant compromise would be received with open arms by the B.E.S.A., whose sole object is to issue specifications that meet with the approval of both customer and manufacturer. The appointment of two of our members to a seat on any of the B.E.S.A. committees does not meet the case. After all, they only express their own opinions and not the voice of the trade. If we as an Institution are not prepared to shoulder the responsibility of putting our views forward, we must accept present specifications without protest.

No. 4.—The real point at issue seems to have been avoided by most members. Their recommendation for the adoption of the transverse has been its simplicity in making—no machining, the cost and supposed lack of straight pull in the tensile machine.

No. 5.—Dr. Hatfield raises an objection to the use of a round bar, cast vertically in dry sand, because of the higher results attained. The round bar, cast in the manner named, would eliminate the danger of wet sand, chilled corners and blow-holes; therefore, the results would be more regular. After all, we all acknowledge the test bar does not always represent the casting, but only the quality of metal we pour into the casting. From Dr. Moldenke's letter it is almost certain this bar will be adopted for international trading purposes. If so, can we expect customers in South America to convert the result of our 1-in. square bar into the 1-2 in. round bar of other nations? Judging by the low tests called for in the American specifications, we in this country have everything to gain by falling into line if comparison of results are an advantage.

The PRESIDENT thanked Mr. Shaw for his Paper and for attending to read it in spite of the difficulties due to his state of health.

The Conference then closed.

Third Day's Proceedings.

A Visit to Messrs. Vickers' Works.

On Friday, September 16, 88 members travelled by electric car from Blackpool to Fleetwood, by steamer from Fleetwood to Barrow, and by char-à-banc from Barrow to the Furness Abbey Hotel. After a brief visit to the ruins of the Abbey, they were the guests of Messrs. Joseph Stubbs, Limited, at luncheon. After the customary loyal toast, the toast of Messrs. Vickers, Limited, Barrow, was proposed by the President, and responded to by Mr. Bannister, director of the firm.

American Foundrymen's Cable.

The President read the following cable message sent to him personally from Chicago:—.

"Behalf of officers and members send greetings, best wishes successful meeting. May exchange inaugurated long continue.—Secretary, American Foundrymen's Association."

The President also read a telegram from Mr. Thomas Mayer, Dumbarton:—

"I am instructed by my father to send you all my warmest thanks for your sympathy and wishes in his present illness and to inform you that he feels much better and trusts the Conference will be a great success."

Mr. Smith (Newcastle) proposed a vote of thanks to the directors of Messrs. Joseph Stubbs, which was seconded by Mr. H. L. Reason and warmly accorded. Mr. J. H. Stubbs responded.

The party returned by char-à-banc to Barrow, where they were conducted over the works of Messrs. Vickers, Limited, by Mr. Bannister and the officials.

The works are described on page 253.

Tea was provided by the firm for the visitors, who returned by steamer and electric car to Blackpool, having spent a day which in every respect was a most enjoyable one, the weather being exceptionally favourable.

During the return journey a meeting was held in the saloon of the steamer. On the motion of Mr. Firth, seconded by Mr. E. Smith, a hearty vote of thanks was passed to the President. In acknowledging it, the President said it was comparatively easy to continue work when a good foundation had been laid, and credit was due to those who had carried on the Institution during difficult times. He had been much helped by others, and in particular the secretary, Mr. Hollinworth, had done a tremendous amount of work behind the scenes of which the majority of the members had no idea. With regard to the future he appealed to the officers of the Branches to send good live suggestions to the Council, and not to slip too much into routine, but to develop new ground and to endeavour to increase the membership. Attention should be given to the social side. During his term of office he would try to visit each Branch, and he suggested that the officials of the Branches should make mutual arrangements to avoid clashing of the occasions on which they particularly desired his presence. Speaking of the industry generally he emphasised the necessity for goodwill in the workshop. He thought it was more likely to be brought about by personal contact of the employer with his own workpeople in his own workshop than by any system of Whitley Councils or organisations of that type. In the Institution they did not have labour matters or commercial matters coming in to divide the members, but they adopted the grand principle of co-operation, and they must see to it that it was carried out.

Mr. M. Riddell added a few words, in which he expressed the view that by social functions the Institution could be developed.

Mr. W. H. Meadowcroft, President of the Lancashire Branch, said they had passed through a very anxious time, but he thought the members would agree that they acted wisely in postponing the annual conference and deciding to hold it at Blackpool. The arrangements had worked out admirably.

Mr. Hollinworth thanked the President and other members for the appreciation expressed of his services.

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Vickers, Limited, Naval Construction Works, Barrow-in-Furness.

These works are amongst the most extensive in the country, and, exclusive of outlying adjacent areas, the main portion covers a space of 270 acres, of which 2½ million sq. ft. are occupied by workshops. As many as 35,000 people can be, and in fact have been, employed at one time, and that without any overcrowding.

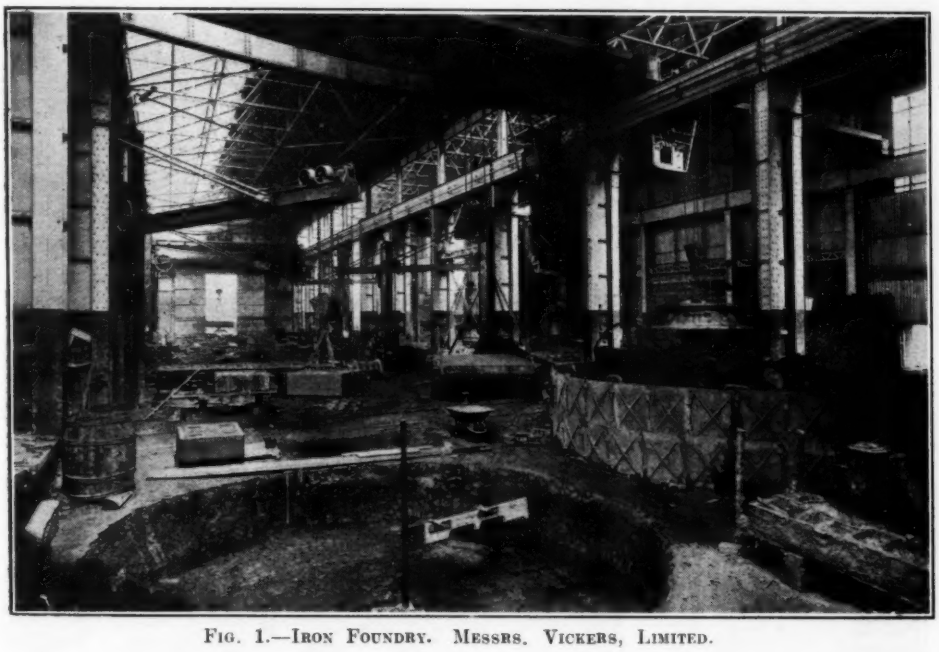

FIG. 1.—IRON FOUNDRY. MESSRS. VICKERS, LIMITED.

In the first instance the works were laid out to undertake the following main lines of production:—Shipbuilding, naval or mercantile, of any description; construction of turbines and reciprocating engines, and subsequently the construction of internal-combustion engines and airships. But since the cessation of war the works have been extended or adapted to manufacture, *inter alia*, electro-hydraulic winches, steering gears, capstans and windlasses, kinetic air-pumps, Contraflo specialities, Michell bearings, gas-blowing engines, locomotive boilers, etc.

General Description of Works.

In the Shipbuilding Section modifications and extensions have been made on a large scale during recent months, and the building berths are now able to accommodate 11 vessels of lengths varying from 330 ft. to 800 ft., besides two others under cover in what is known as the new submarine shed.

FIG. 2.—BRASS FOUNDRY. MESSRS. VICKERS, LIMITED.

These two berths are each 390 ft. in length and suitable for building yachts, cross-Channel craft, submarines, torpedo boat destroyers, etc. In addition, two berths are arranged in the North Yard capable of taking boats up to 450 ft. in length. There is a total of nearly 1½ miles of building berths.

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FIG. 3.—AERIAL VIEW OF NAVAL CONSTRUCTION WORKS. MESSRS. VICKERS, LIMITED.

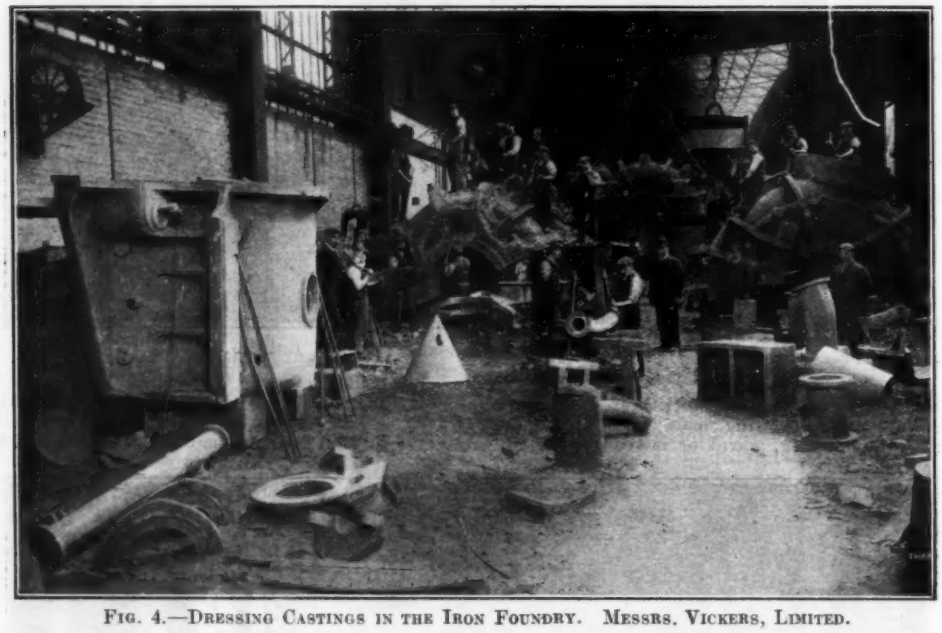

FIG. 4.—DRESSING CASTINGS IN THE IRON FOUNDRY. MESSRS. VICKERS, LIMITED.

FIG. 5.—SECTION OF LARGE TURBINE CASING FOR H.M.S. "PRINCESS ROYAL."
MESSRS. VICKERS, LIMITED.

There are two platers' sheds, each equipped with the necessary punching, shearing, flanging and other machines, to the total number of 192. The fitting-out berths at the Devonshire and Buccleuch Docks are capable of accommodating the largest class of vessel extant, and at each dock is erected a 150-ton cantilever crane by which the machinery and all heavy gear can be lifted. The deep-water berths in the Walney Channel were specially dredged for the use of Messrs. Vickers, and has been found invaluable for the completion of float-

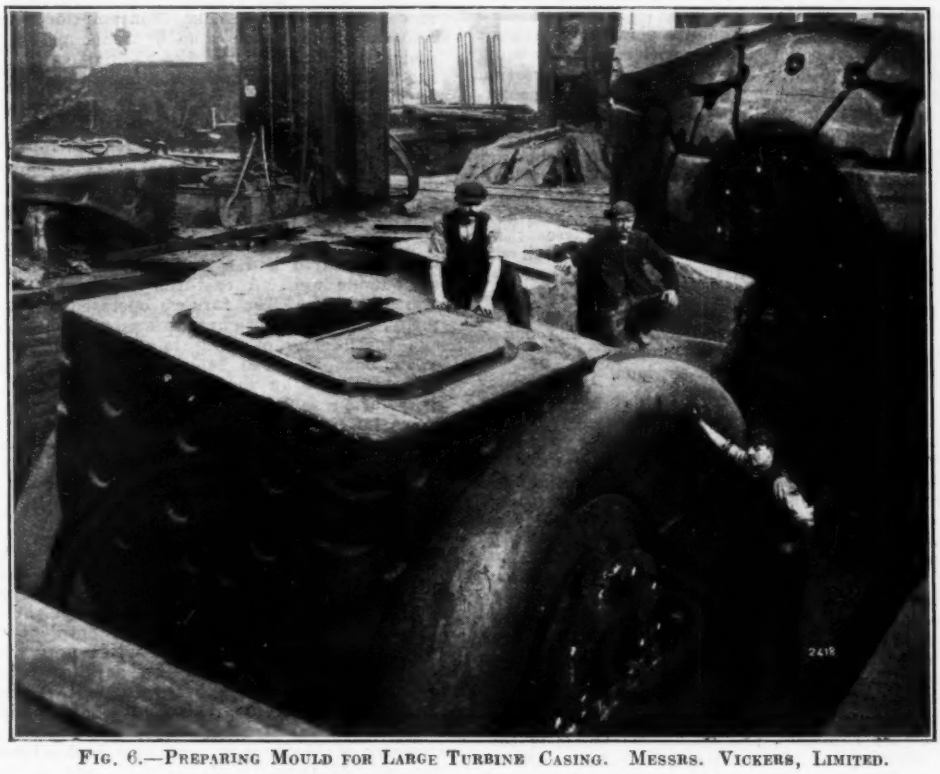

FIG. 6.—PREPARING MOULD FOR LARGE TURBINE CASING. MESSRS. VICKERS, LIMITED.

ing docks, etc., which are too wide for entry into the other fitting-out berths. The old floating dock is now replaced by one of later design and much greater capacity, which will facilitate the completion of vessels and enable a larger amount of repair work to be undertaken. The graving dock at the north entrance is often utilised by the firm for some of their extensive alteration and repair work.

The engine department was intended in the first instance for the manufacture of steam-driven propelling machinery for any type of vessel, and at the present time, in addition to several sets of geared turbines and of reciprocating engines, is busy with the manufacture of Michell bearings, gas-blowing engines, etc. The submarine engine department originally confined itself to making internal-combustion engines, but has recently extended its activities to embrace electro-hydraulic winches, steering gears, capstans, windlasses, boat hoists, sidelights and moulding machines.

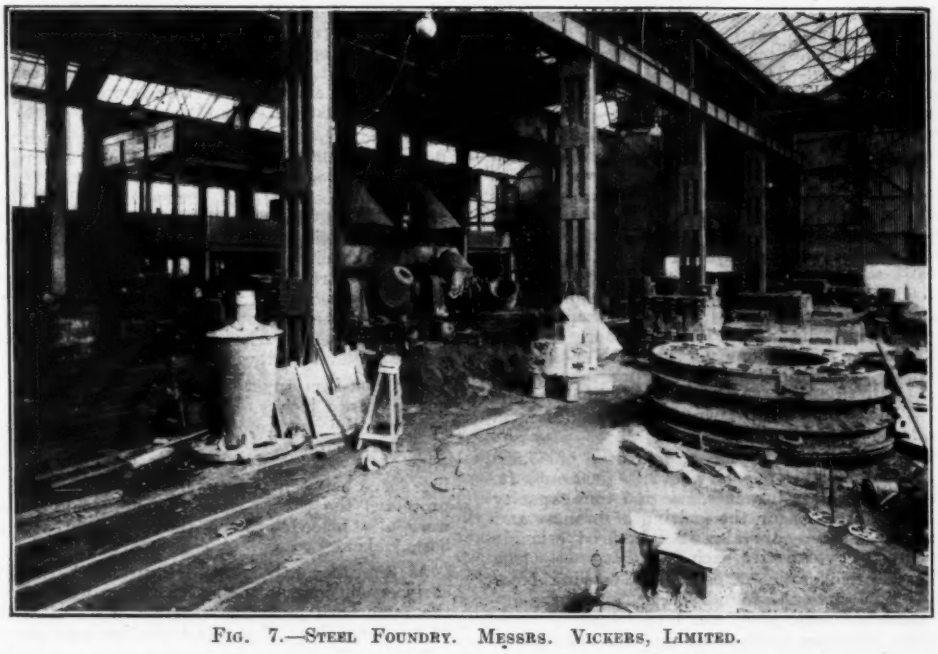

FIG. 7.—STEEL FOUNDRY. MESSRS. VICKERS, LIMITED.

The ordnance department is now largely taken up with repairs to locomotives for all the main lines, and these can be seen in various stages of completion. The howitzer shop has proved itself

useful for the manufacture of electric locomotives for the Metropolitan Railway Company, whilst another purely wartime building, viz., the new shell shop, has been mainly taken over for the manufacture of rubber-making machinery. The remainder of this building is now given over to shipyard mechanics and other people who have been removed to allow for extensions. Here, also, much locomotive work is being done. A new line has been taken up by the ordnance plating department in so far that boilers for locomotives are now being made in large quantities. The ordnance erection department has the manufacture of several centrifugal separators, and this is a branch which will probably develop. The gun-mounting department has commenced upon the making of stone mills and crushers, and will be laid out for further work in this direction, as many more orders are anticipated in the near future.

In addition to the ship smithy, there is an engine works smithy, in which practically all the necessary smithing and forging for the machine shop are done, as well as stampings in large quantities. Practically the whole of the machinery in the Yard is electrically-driven, and the power necessary for this and for lighting purposes is obtained from two large power stations.

Foundries.

The works are provided with three separate foundries for the production of steel, iron and brass castings on an extensive scale. An essential feature in the design of foundry buildings is the necessity of providing ample space, light and ventilation, in order that the smoke and fumes inseparable from the foundry processes shall not militate against the general health and efficiency of the workmen, and it will be found that, in this respect, the Vickers' foundries leave no room for criticism.

The installation of plant is of the most modern type. Each foundry is equipped with Macdonald moulding machines of the largest and most efficient pattern: pneumatic rammers are installed for the use of the moulders, and pneumatic hammers for the cleaning of the castings, together with a thoroughly up-to-date sand-blast plant for fettling purposes. The general lay-out of these foundries and the equipment with which they are provided, combined with the foregoing advantages, have enabled Messrs. Vickers, Limited, to produce all the classes of castings, large and small, required in the manufacture of the infinite variety of engineering products of these works.

The following particulars relating to the different foundries may be of interest.

Steel Foundry.—This portion of the works has a floor area of 30,000 sq. ft., and the buildings have a cubic capacity of 1,350,000 cub. ft. There are installed three Tropenas converters capable of converting 2 tons per blow each, whilst the floor is served by seven electric cranes varying in capacity from 5 to 30 tons. There are also five 5-ton hydraulic jibs. The foundry is capable of turning out castings from 20 lbs. to 10 tons.

Iron Foundry. This building has a floor area of 45,000 sq. ft. and a cubic capacity of 2,025,000 cub. ft. The cupolas include one 8 ft. dia. melting cupola to deal with 12 tons per hour, one 5 ft. 6 in. dia. for 7 tons per hour, and one 4 ft. dia. to melt 4 tons per hour. The floor is served by six electric cranes varying in capacity from 15 to 45 tons, together with 5-ton hydraulic jibs. The foundry can turn out castings of from 2 oz. to 60 tons.

Brass Foundry.—This has a floor area of 55,500 sq. ft. and a cubic capacity of 2,220,000 cub. ft. There are three air furnaces, two of 7 tons capacity and one of 5 tons, for the melting of bronzes and gunmetal. There are also 42 coke-fired crucible fires of 300 lbs. capacity each.

Five electric cranes of capacities varying from 5 to 15 tons serve the foundry floor, and there are also eight hydraulic jibs from 1 to 3 tons

At the cessation of the war and the consequent falling-off of the demand for brass casting for ordnance and other work, two Thwaites cupolas, each capable of melting 5 tons per hour, were installed in the brass foundry to cope with the great demand for iron castings then existing.

Two large pattern-shops are kept constantly employed in making the necessary patterns for these foundries.

Increasing the Efficiency of an American Blast Furnace.

MR. LOUIS M. HARTWICK, in a recent issue of "The Iron Trade Review," describes how the output of one of his company's blast furnaces was increased and its coke consumption greatly reduced at the same time by reducing the bosh diameter, increasing the hearth diameter, enlarging the bustle pipe, and other improvements.

The furnace in question was one of two stacks at the Low Moor plant in Allegheny County, Va., U.S.A. Just before blowing in for the fourteenth blast, the furnace had a hearth 11 ft. 8 in. in diameter, and a bosh diameter of 19 ft. The bosh angle was 74 deg. 53 min., and the height of the stack 80 ft. The bosh was provided with a steel jacket of ¾-in. plate cooled by spray pipes, and the hearth had a cast-iron jacket cooled by an outside well. A cast-iron tuyere breast was also provided. The furnace operated unsatisfactorily, the fuel consumption was unusually high, and the number of off-heats was large. In the early part of 1920 the lining became badly scaffolded, and an investigation proved the stack distribution faulty. Therefore, the furnace was blown out in June, 1920, but it was necessary to blow it in again as soon as possible in view of existing market conditions.

After a careful study of the problem, it was decided to retain all of the old hearth construction including the flat angle bosh jacket, which in the opinion of most furnace engineers was not the best practice. In this connection the conclusion was reached that bosh angles were given more consideration than was due to them and that the smooth working of a furnace was not dependent upon a steep-angled bosh, but satisfactory operation could be accomplished just as effectively by making the bosh angle bear a definite ratio to the hearth or tuyere area. Thus the new lining was designed maintaining the old hearth lines and diameter of 11 ft. 8 in., but the bosh diameter was reduced from 19 ft. to 16 ft. and the bosh line lowered.

To avoid using too many bricks in an excessively thick inwall, a back lining was laid in cement against the old brick shell. Also slight operations were made in the distribution, which corrected most of the error at this point. On these new lines a large saving of coke was effected and the furnace made practically no off-heats, working on specifications ranging from low-silicon to 6 per cent. silicon iron and producing tonnage equal to the expectation. The improvements made were well justified.

Last March it was decided to further modify the design by additional improvements to secure still greater efficiency in the sixteenth blast. The improvements consisted of a new steel-plate hearth jacket 20 ft. in diameter of 1¼-in. steel plate, cast-iron cooling plates placed inside the jacket for the full circle, and a new bustle pipe of 48 in. diameter to replace the old 36-in. pipe, which was considered too small to distribute the blast properly. The hearth jacket extends 3 ft. 6 in. below the hearth level. The cooling plates extended to the same level and were 3 in. thick.

The cast-iron tuyere breasts were retained, but new distance blocks of cast iron were made to go between the tuyere breasts to give the proper diameter. Holes were cast in these blocks to provide for copper cooling blocks. This gave a cooling space between the tuyere coolers and thereby protected the tuyere zone. Copper cooling plates were also placed between the tuyere breasts and bosh jacket.

As the fifteenth blast demonstrated that the early conclusions as to the bosh lines were correct, the same bosh jacket, having an angle of 74 deg. 53 min. was kept, but the bosh line was lowered.

Following the most recent improvements, the stack now has a hearth of 13 ft. diameter, bosh of 17 ft. diameter, and bosh angle of 74 deg. 53 min. The height of the stack is 80 ft. and the bell is 8 ft. 6 in. in diameter. The batter of the inwall is 8 in. in 10 ft. or practically ⅞ in. in 1 ft. On these lines it is expected that the production of the stack will be materially increased.

XUM

Some Perplexing Foundry Problems.*

By J. Shaw.

The Author will be pleased if members will look upon the following statements as the introduction to a discussion, rather than as a paper in the usual sense.

It is quite difficult to reconcile the various views put forward by authors concerning some phase of our work.

Reference was made last year in Professor Andrews' paper to the bad effect of oxide inclusions in cast iron. This year Mr. Elliot mentions the same fact. Yet there are eminent metallurgists who deny that any oxide can be present in an iron containing over 0.3 per cent. silicon, and those who state that oxide is beneficial to the iron and actually blows air into the metal to improve its quality.

Pickard in his Carnegie Research (page 76, Carnegie Memoirs, 1916), states: "The chief interest attaching to the results is that they show that oxygen is present in material from which it has usually been assumed to be absent; and that an amount of oxygen which would be important if found in steel may exist in material containing even such comparatively large amounts of silicon (0.699 per cent.) Carbon (3.24 per cent.) Manganese (0.53 per cent.) as commercial cast iron (0= 0.021 per cent.)."

Dr. Hatfield ("Foundry Trade Journal," August, 1920, page 620) during a discussion gave it as his opinion, "That if there was more than 0.3 per cent. silicon in the iron, that iron was free from oxide." A liquid iron containing, say, 1.3 per cent. silicon, 1.0 per cent. phosphorus, and 0.6 per cent manganese was one which J. E. Johnson Junr. said might contain oxygen. But he (Dr. Hatfield) said quite definitely such iron could not contain oxygen, because the silicon, phosphorus, and the manganese had a much greater affinity for oxygen than the iron in which they were dissloved, and the result was that, before the oxygen could form oxide of iron and so be dissolved in the iron, it would form oxides of those elements, which would come to the surface, and so be eliminated from the iron, by specific gravity alone."

Elliott's view, viz., "That oxides do exist in cast iron in appreciable quantities, but that their action is detrimental" is held by many people, including P. Munnock (B.F.A. Proceedings, 1908), Houghton (B.F.A. Proceedings, 1908, page 44), Professor J. Porter (Foundry, October, 1912) and Dr. Moldenke (Principals of Ironfounding). The last authority states, "This problem can undoubtedly be traced back into the blast furnace. It is perfectly possible that the difference between a pig-iron, which shows superior strength on being broken and another of the same composition, which breaks readily, lies simply in the percentage of oxygen retained in passing through the reduction from ore to metal, or more likely in a slight re-oxidation of the melted iron sponge as it passes by the tuyere zone of the blast furnace.

When it is remembered that with apparently identical compositions, there are definite qualities inherent in various brands of cold-blast and warm-blast charcoal-irons, as also in hot-blast coke irons, which manifest themselves in greater or less strength, machinability and fineness of structure, there must be a reason for this situation other than a mysterious agency or heredity ore qualities transmitted to the pig-iron (the view still held by many old-time furnace and foundrymen). This reason, the Author has for many years claimed to be the extremely small percentages of dissolved iron oxides in the several classes of pig-iron in question."

J. E. Johnson, Junr. (Foundry Trade Journal, April, 1914), (A. F. Association Proceedings, 1914), and Wilford L. Stork, (Foundry Trade Journal, July, 1919), go a step further and state that oxide not only can exist in iron containing 1.88 per cent. silicon, but that its effect is beneficial.

Johnson states, "That in the course of an investigation extending over two years and carried on by means of physical tests, remelts, photomicrographs, and direct determinations of oxygen, we found that all abnormally good irons contained oxygen to the extent of 0.04 to 0.10 per cent. that the normal charcoal irons contained 0.015 to 0.025 per cent.

We went further, and put oxygen into normal and poor irons by remelting them with a highly oxidised product made only when the furnace had been in trouble and was working too cold to make merchantable iron. By this means we made iron as strong as the best the furnace ever produced. We also tried weakening these strong irons with deoxidisers, and whilst we could not get out very much oxygen, we reduced it enough to reduce the strength."

The above quotations put very briefly the various views held.

The Author's interest in the question dates back about 15 years, when he had charge of a foundry connected with a firm who owned blast furnaces. This furnace was often on a forge-iron burden, and any iron too grey for forge purposes was transferred to the foundry side. Often when the grey forge-iron was melted in the cupola the resultant metal in the ladle showed a curious visible phenomenon. When the ladle of molten metal was skimmed off, and the usual oxide film covered the surface of the metal due to its contact with the air, there appeared under this film spots which immediately spread to the size of a shilling. There appeared to be some chemical reaction taking place accompanied by heat, because these spots were of a higher temperature than the surrounding metal. If the ladle was allowed to stand for a time, as the temperature of the metal dropped, the spots turned black as they came to the surface and spread out. If the oxide film on the top of the metal was now pushed aside, these black patches could be taken from the top of the metal, and would have the appearance and composition of hammer scale.

It must be borne in mind that during the reaction, if such it was, the top oxide film was not broken, nor did any flame appear as is usual. This phenomenon was of such common occurence that all the moulders recognised it at once. Their trouble was that no matter how hot the metal was melted, it lacked life when run into the moulds, and short cold-shuts on the top side of the castings often showed under the water test.

Taking it for granted that oxide inherent in the iron as received from the blast furnace was the cause, the Author made small additions of finely powdered 80 per cent. ferro-manganese down the spout of the cupola as the metal was tapped. This stopped the appearance of the spots at once, and the resultant metal was more fluid. The small additions of ferro-manganese had not altered the composition of the metal so far as an analysis showed. It is stated that an increase of oxygen adds to the depth of chill. It should be pointed out, however, that if small amounts of aluminium be added to the ladle there is a decrease of chill. Whether this is due to its deoxidising effects, or to its action on the carbon, acting to some extent similarly to silicon, is a moot point. It is thought oxygen does strengthen cast-iron, causing the graphitic carbon to be present in a finely divided state, and the Author agrees with Elliott that its lack of life and tendency for blow holes, etc., make it undesirable under cupola conditions. At the same time, it must be remembered that Johnson took his metal direct from the blast furnace, and thereby obtained that amount of superheat in his metal that might overcome these troubles.

The next point to be emphasised is the great discrepancy that often occurs between the physical properties of cast iron and its chemical content, even when the iron is from the same ores and furnace.

That there is a difference between irons of the same composition when made in a cold-blast charcoal furnace and a hot-blast coke furnace, for instance, is now generally conceded.

It should not be taken for granted that the above statement implies an attack on chemical analysis; no one sets a higher value on its use than the

* Paper read before the Institution of British Foundrymen's Annual Conference, Blackpool, September 14, 15, 16, 1921.

Author, but it is a warning that with the use of faster driven furnaces, the use of small ore and often poor fuel, there probably is on the market large quantities of pig-iron whose physical tests would not be what one would expect from the chemical analysis. Most of us remember the series of tests made by Cook and Hailstone (Proc. 1908 and 1909), in which the lowest results of one set were higher than the best of the other set, although the chemical analysis agreed within practical limits.

Pilkington (Proc. 1905 and 1906), in speaking of what is known as "Over Grey" pig, states, "The fracture when cold is a very wild and scattered one, and would in all possibility be graded as a No. 4. The analysis would be equal to a good No. 1 (see below). If the usual amount of scrap that a No. 1 carries were melted with this iron in the cupola, the resultant casting would be very much harder than usual; in fact, in many classes of work it would give trouble. It has been said that whatever may be wrong with the pig-iron in its carbon, that when re-melted, that carbon is all restored to its normal condition in the casting. It does not appear possible to controvert such a statement, but the class of iron just referred to is *not* restored to a normal condition, and I am afraid is little known to metallurgists."

Houghton in a paper the following year confirms the above statement. He also gives the analysis of one of these "Over Grey" pig irons, which is as follows: T.C. 3.53 per cent., G.C. 2.95 per cent., C.C. 0.58 per cent., Si. 2.94 per cent., S. 0.007 per cent.

Munnock (Proc. 1908), in reply to a statement that in 99 per cent. of cases the composition agrees with analysis, answers, "I can hardly agree to 99 per cent., but I should say in, perhaps, 50 per cent." Adamson (Proc. 1916), gives us a large number of examples where the fracture bears no relation to the chemical content, one of which, supplied to him by Sir R. Hadfield, had the following composition: T.C. 3.28, G.C. 2.22; C.C. 1.06, Si. 0.35, S. 0.026 per cent. Yet the fracture was grey.

The Author can substantiate Pilkington's remarks about "Over Grey" pig-iron, having used large quantities. There is no recovery of structure on re-melting, that would be expected from the analysis. Perhaps the most curious example of this non-recovery was one that occurred when our furnace was aiming for a low-silicon iron, with about 1.0 per cent. manganese. One cast of about 25 tons had this remarkable analysis: G.C. 3.15 per cent., C.C. 0.54 per cent., S. 0.035 per cent., P. 0.44 per cent., Mn. 0.97 per cent., Si. 0.18 per cent. Yet with this Si. of 0.18 per cent. the iron was perfectly grey. The whole 25 tons was remelted and cast into shell containers. These were machined all over inside and out.

The containers gave excellent results, averaging over 900 shells each. So there could be no doubt about the analysis the Author carried pieces of this pig-iron about for some time to various meetings. The contents were checked at least six times by competent chemists, one of whom melted down a portion in a crucible, and cast plates ¾-in. thick, which were perfectly grey.

Granting at once that the above iron and also those mentioned by Adamson are freak irons, but what of the large quantities of iron where the divergence between the fracture and the chemical analysis is not so marked? Would not this alone account for many of our physical test failures when the analysis seems quite satisfactory?

The third point relates to the lack of uniformity and lax manner of stating the results of tensile tests. With regard to this matter of tests, our whole criticism has been destructive, rather than constructive. We, as an institution, have not submitted our views in a concrete form for the consideration of engineers and metallurgists. It is, no doubt, due to this lack of definite proposals that we, as an institution, have not participated in the preparation of British Standard Specifications in which cast iron is mentioned. Candidly, it is our own fault. What are engineers to think when some members are boasting that they are obtaining tensile tests up to 21 tons per square inch, whilst many others have difficulty in reaching 10 tons? In many cases this is due to the great variation in the diameter of the tensile bar as cast, as much as variation in composition.

Whilst at the Ministry of Munitions the Author had a unique opportunity of investigating this question. He found tensile bars varying in the breaking portion from approx. ⅜-in. diameter (¼-in. square) to 1.128-in. diameter (1-in. square) in use. Having received reports from another department of abnormal tensile strengths being sent in by several firms (up to 20 tons per square inch), he found in each case the small bar was in use. On another occasion, whilst a committee was sitting to draw up specifications for certain castings, it was urged by some members that in order to obtain the necessary resiliency for this type of work a tensile strength of 17 tons was needed. As these members were most successful with this class of job, their recommendation carried much weight, and 17 tons was provisionally accepted for the test. But when learning that these results (17 tons) were obtained on a bar less than the B.S.C. tensile test-piece (which was the one adopted for this specification), it was decided that 24 test bars of each size were to be made and cast from the same metal. The result was that, whilst the smaller bar still went up to about 17 tons, the ⅜-in. diameter bar turned in the centre to .654-in. diameter fell to about 14 tons. Most of you will remember the example given by one of our presidents. An inspector objected to the high tensile strengths he obtained being so much above the specification. Knowing the mixture was most suitable for the work in hand, the diameter of the cast bar was increased, then turned down to the same size as before. When broke, it gave three tons less and met the objection raised.

It would be easy to multiply these examples, but sufficient has been said to show us how vital the matter is.

There are two ways of facing the problem, which is not the easy one it at first seems. Either to have three different sizes of bars to match the composition of light, medium and heavy castings, or have one diameter of bar with specified tests varied with the thickness of the casting the test bar represents. The first has been tried by both America and Germany so far as the transverse test is concerned. Whilst there was distinct theoretical and practical advantages in having the size of the bar to bear some relation to the thickness of the casting it represents, its use was found so cumbersome in work that it was dropped.

At the International Society for Testing Materials meetings in 1913 a standard bar 1.2-in. diameter tested on supports 18-in. apart was provisionally adopted for international trading purposes.

The great objections to the American Standard Specification are, firstly, that 12-in. centres are too short to register fine correct deflections on a 1¼-in. diameter bar; secondly, if 21,000 lbs. represents a fair test for castings varying from ¾-in. to 1¾-in. thick, we should expect the test load for 2-in. castings to be less per square inch, instead of the higher figure given in the specification. It stands to reason that if the mixture was made to give the maximum strength at 2-in. thick and over, it would be too hard for a 1¼-in. round bar, and a drop in strength would result.

The Author does not think it the best policy for the Institution to issue specifications of their own. We have a British Engineers Standards Association who would be only too pleased to have our direct co-operation. Many of us feel that unless the foundrymen put up some definite proposals to meet this problem, it will continue to be done for them in a way that does not meet with their approval. There is no doubt that proposals from us would meet with a very good reception from the Standards Association who would probably co-opt members to state their views.

The last point, and one which will meet with much opposition, is this—I do not think, so far as cast iron is concerned, that the tensile-test is as good as the transverse-test is, as a measure of the *quality* of the iron. The tensile-test is more a measure of the structure of the iron, rather than its quality. Put another way, there is no difficulty in conforming to the tensile strength of 9 or 10 tons asked for on a 1.128-in. diameter bar, with any common iron, if the combined carbon is about 0.8 to 1 per cent. according to the composition. But it is most difficult to obtain 28 to 30 cwts. on the 2-in. by 1-in. by 36-in. centre bar with the same common mixture.

Whilst there is some truth in the statement that the moulding and running of these long transverse bars add to the risk of obtaining regular results, this does not meet the whole case. From a log, in which we recorded many thousand tests, covering a number of years, it was curious to note how regular were the results of the tensile-tests, and often how irregular were the transverse-tests. It was almost possible to form an opinion of the burden of the blast furnace during certain high and low transverse-test results. Perhaps a further illustration will help. If we found the iron from the cupola was not up to the transverse-test, it was possible, by adding one pig of a No. 5 high-class iron to a 20 cwt. charge, to raise the transverse-test one cwt. Add two pigs to each charge—a further cwt. on the test would be gained. A third pig to each charge would lift the transverse-test up to 3 cwts. The tensile strength would certainly rise a little, but nothing like the eight times the transverse, which is a rough calculation for the 2-in. by 1-in. by 36-in. bar.

There are so many side issues to the points raised that may lead nowhere, yet hinder us from forming any definite conclusions, that the Author would consider it a favour if speakers would confine their remarks as far as possible to the heads enumerated below:—

(1) Can oxygen be found in appreciable quantities in an iron whose chemical analysis would mark it as suitable for making strong grey iron castings? If so, is it beneficial, or otherwise?

(2) From the examples cited in the paper, it is evident that in some pig-irons, even on remelting, the fracture does not conform to what might be expected from their analyses. Granting these cases, is it not possible that large quantities of pig-iron possess these inherent qualities in a lesser degree? May not this acount for some of the divergent results met with between physical tests and chemical composition?

(3) Is it not in the best interests of this Institution that some Standard Specification should be put forward for consideration of the B.E.S.A. so that the various tests might be comparable?

(4) In view of the fact that America, Germany and Italy have adopted the transverse test as a standard, with the tensile in most cases optional, is there any evidence that the transverse test for cast iron gives a better idea of the quality of iron, rather than the tensile?

(5) Would not a circular bar as adopted by the International Society for Testing Materials, cast vertically and drysand, overcome some of the difficulties of moulding and running, attributed to the 2-in. by 1-in. by 36-in. bar for transverse-tests?

Welding Ladle Spouts.

An interesting account of the manner in which worn-out ladles were repaired at the works of the Garfield Smelting Company, Garfield, Utah, U.S.A., was given in a recent issue of the "Engineering and Mining Journal" by Mr. E. J. Harris.

Repairs had previously been attempted by riveting patches of sheet steel around the spouts. The result, however, was very poor, and it was determined, before buying new ladles, to try thermit welding in a new spout on one ladle as an experiment, which was done with such satisfactory results that other defective ladles were treated in the same manner at a quarter of the expense entailed in buying new ones.

First a pattern for a new spout was built, and a cast-steel spout made from it. The old spout was cut out from the ladle and an allowance made of 1 in. between the edges of the new spout and the space occupied by the old spout. The edges of the ladle and the spout inside and out were then chamfered, making the edge of both V-shaped, and the new spout fixed in place by three bolts. Pattern wax was then prepared and moulded in place the exact shape of the weld wanted, which was 4 in. wide at the body of the ladle, 1 in. for space between spout and ladle, ½ in. each side for chamfering, and 1 in. each side for a collar.

In moulding the wax which gave the contour of the weld, a piece of ¼-in. wire was placed in the centre of the wax all round the joint. When the wax was set the wire was pulled out. The space occupied by the wire gave the heat a chance to circulate and hastened the removal of the wax when it was melted out after the mould was formed. A piece of small rope is sometimes used in place of the wire. The ladle was then tipped at an angle of about 90 deg., with the spout down. When in this position the pouring gates, of which there are two, one at each juncture of the spout with the ladle, are on the outside edge of the ladle and spout, the riser being at the base of the spout. Care must be taken to see that the riser is a trifle higher than the pouring gates.

A brick platform or mould was then built from the ground up to within 6 in. of the spout, heavily

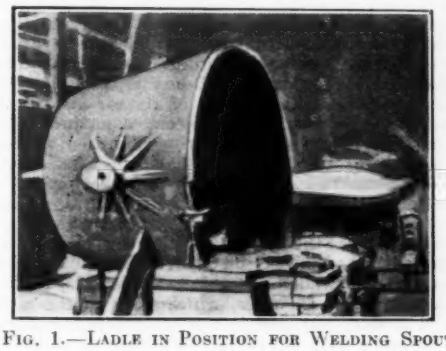

FIG. 1.—LADLE IN POSITION FOR WELDING SPOUT.

reinforced all around to prevent the pressure of the melted thermit from forcing its way through. The 6 in. between mould and spout was filled with a mixture of silica sand, ground firebrick and fireclay in equal proportions by bulk. In mixing, particular care was taken to see that just enough water was used to allow the mixture to hold together. The mixture was then tamped as tightly as possible between the mould and parts to be welded.

A small mould of brick was made for the inside of the ladle, and the mixture of silica sand, ground firebrick and fireclay tamped in, arrangements being made for the riser, pouring gates, and pre-heating holes. The pre-heating holes were, of course, in line with the joint to be welded, and

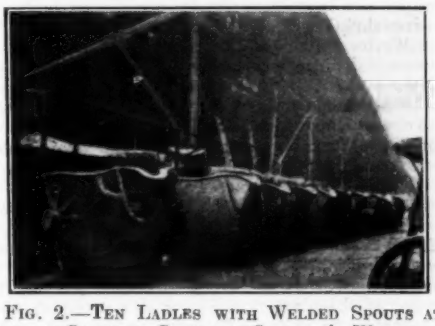

FIG. 2.—TEN LADLES WITH WELDED SPOUTS AT THE GARFIELD SMELTING COMPANY'S WORKS.

the pouring gates and riser, on top of the joint to be welded, or inside the body of the ladle. The wax was melted out by using the pre-heating torch, and the joint brought to a red heat, kerosene being used for this purpose in the pre-heating torches.

All these welds have successfully withstood the battering action of knocking out the shells, which was the cause of breaking of the original spouts.

United States Taxation.—A cable from Washington states that the Administration's Tax Revision Bill, designed to raise 3,000 million dollars a year, has been formally presented in the House of Representatives. The Republican leaders estimate that the Bill will reduce the nation's tax burdens by $600,000,000 in the next calendar year, through (1) the repeal of the Excess Profits Tax, (2) the higher branches of the income surtaxes, (3) all the transportation taxes, including those on express and oil-pipe lines, (4) increased exemptions granted to heads of families and married men having small incomes, and (5) decreases in the taxes of certain commodities.

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Some Written Opinions on—"Some Perplexing Foundry Problems."

American Observations.

DR. RICHARD MOLDENE (Watchung, N.J.) wrote: He was glad that you are also very much alive to the question of oxygen in cast iron. The difficulty he noticed with those who object to the possibility of oxygen being present in cast iron is that they assume it must be either the occluded gas or solid particles of an iron oxide—which, as Dr. Hatfield rightly holds, must needs rise out of the molten metal and go with the slag.

As a matter of fact, however, the oxygen is present as a dissolved iron oxide, and you have only to study the steel-making process to understand the situation. Whether in the Bessemer or in the open-hearth processes, the oxygen of the air attacks the first thing it gets, iron, silicon, manganese, carbon, irrespective of the varying affinities of these elements for it. The oxide of iron, as a matter of fact, serves as the carrier for the oxygen to the impurities to be removed. This oxide of iron is dissolved in the molten bath.

Now what is the cupola process other than a very small edition of the Bessemer furnace? The reactions are the same, and the metal can be (and is) slightly charged with iron oxide, which stays in the metal when it sets. Dr. Hatfield is, therefore, somewhat at variance with actual facts as they occur in the cupola, for phosphorus, silicon, manganese and carbon do not prevent iron from oxidising when in contact with air at the temperatures involved. Even Prof. Howe now admits that oxygen (in the form of dissolved iron oxide) can be present in cast iron in spite of 4.00 per cent. total carbon, high silicon, etc.

He differed with Johnson, and fought him right along on his oxygenation process. He held that Johnson was correct enough in stating that oxygen in iron hardened it (deepened the chill) and strengthened it, but the Writer claimed this was an indirect result of the oxygen—in that the solution of an appreciable quantity of iron oxide raised the freezing point. Therefore, the metal set quicker, and thus gave a higher combined carbon content, was stronger and chilled deeper. He could get the same thing by reducing the silicon proportionally, and did not introduce the danger of blow-holes, excessive shrinkage, etc. Johnson is now dead, but the Writer understands that even at life-time his process fell into disuse, as it did not work out satisfactorily.

The Author's tests with ferro-manganese simply prove the contention. You remove the dissolved iron oxide by taking away the oxygen by the manganese addition.

What you write about "freak" pig-irons is interesting. We run across them here occasionally also, but they are all of them, bear in mind, the result of furnace trouble culminating in an incomplete reduction of the ore, or a re-oxidation of the iron sponge or molten iron, either by CO_2 or the oxygen of the blast as the tuyeres are passed. Such iron cannot be restored in cast-iron practice, and is even supposed to make indifferent steel. The foundry were well rid of it. Over here we no longer consider fracture in pig-iron, and hence our foundrymen are no longer on the look-out for poor fractures, particularly as much of the iron is machine cast.

The Author's remarks on the tensile test are to the point. Personally he did not like it for cast iron because of the chance of an uneven pull. Your objection to the American bar is correct; it is a little too short, hence we are figuring on a longer bar where international work is being tested. The 1.20 in. dia. bar tested on supports 18 in. apart seems best adapted for the purpose. He was now at work on a lot of these bars to see how they compare with the A.S.T.M. standard (the American standard), as the time seems about ripe to take up the international testing work again. His correspondence and personal interviews here and abroad indicate this.

H. E. DILLER (Cleveland, Ohio) wrote: A debate on the first issue presented by Mr. Shaw would, no doubt, be won by the speaker with the greatest eloquence and the most logical imagination, because practically no scientific data are available to prove whether oxygen is beneficial or detrimental to cast iron. The facts seem to indicate that both sides are correct, and that, under certain conditions, oxygen is a distinct advantage to cast-iron, while under different conditions it is a decided disadvantage. Johnson probably did more scientific investigation of this subject than anyone else, but his conclusions that oxygen is beneficial to cast iron have not been generally commercialised. On the other hand, every practical foundryman knows the deleterious effect produced when iron is over-oxidised in melting, or, at least, when the melting conditions are such as to produce the effect which is called "burnt iron." Two effects which strengthen iron are attributed to oxygen by a few metallurgists, although other factors are involved. The one is smelting with a warm or cold blast instead of the extremely hot blast generally used in modern blast-furnace practice; and the other is adding steel to the mixture in the cupola. Various theories are advanced to account for the strengthening of the metal by these processes, but none of them has been proved beyond dispute. Certainly, if oxygen is the cause, it has not been determined unquestionably. The accuracy of the methods advanced for the quantitative chemical determination of oxygen in cast iron has been questioned, and no one has offered any method of detecting oxygen in grey iron microscopically. It would, therefore, seem that the first step towards determining the effect of oxygen on cast iron must be to evolve a correct method for quantitative determinations, and this should be reasonably simple.

Then, after a method for determining the amount of oxygen present has been worked out, the different forms in which the oxygen could exist in iron should be decided and a means of determining the percentages in each form should be found. At present theories are advanced to support the contentions that the oxygen exists as an occluded gas, as dissolved ferrous oxide, and as undissolved ferrous oxide. Possibly in one of these forms it is injurious and in another it is beneficial.

The method of smelting pig-iron has such a marked effect on the quality of hot-blast and cold-blast irons that it is reasonable to conclude that this effect is impressed on different brands of hot-blast or of cold-blast iron, and even on iron from the same furnace from day to day. Many furnacemen recognise this, and break pig-iron from different shipments to examine the fracture. Pig-irons which show holes or dirt near the upper surface are looked upon with suspicion. The brand of pig-iron is considered so important by some foundrymen in special lines that extensive trials are made before adopting a new brand of iron for their mixtures. One company manufacturing rolls had many microscopic tests made of a new brand of charcoal iron offered to it before adopting the particular brand of iron for its use.

Commenting briefly on issues 3, 4, and 5, as raised by Mr. Shaw, it might be well to call attention to the fact that all American foundrymen are not agreed that the 12-in. by 1¼-in. round bar is the best one, some preferring the 1-in. square bar and others the bar with 1-in. by 2-in. cross section either 18 or 24 in. long. It is, however, generally conceded that the best method of casting the round bar is on end in a dried-sand mould. In this way the hottest iron is at the top, and has a strong tendency to carry with it any slag or sand which might be caught in the mould. One drawback is that the iron, as it strikes the bottom, has a tendency to splash and throw globules of iron against the side of the mould. These solidify and are not always re-melted, but sometimes remain in the test bar to be found near the surface when it is broken.

The advantages claimed for the transverse test are that it does not require machining, and so the transverse test can be made cheaper than the tensile test. Also, the transverse test can be made on a simpler machine than is required for the tensile test. This latter item is quite a consideration to the smaller company operating a foundry. Then, too, the transverse test gives more concordant results than the tensile test, which is affected markedly by the alignment of

the machine, owing to the extreme rigidity of the metal under test. The tensile test is also affected to a great extent by the shape of the test bar, a slight change in the fillet having been shown to make a difference in the results of as much as 2 tons per sq. in. in extreme cases. Again, the results obtained from both tests are increased by pouring the metal as hot as possible. Thus, if the test bar is poured before the casting, and enough time elapses between the pouring of the two, the iron in the casting may be considerably weaker than that in the test-bar. This is one factor indicating the advantage of casting the test-bar on large castings.

MR. GEORGE K. ELLIOTT (of Cincinatti, Ohio, U.S.A.) wrote: It gave him pleasure to contribute to the discussion of Mr. Shaw's Paper, but, through the lack of time, he was forced to limit himself to the first two of Mr. Shaw's five points with which his Paper is concluded.

He was constrained, in the light of present knowledge, to believe that oxygen does remain in appreciable quantities in grey irons of the compositions that commonly are approved for castings of strength. Possibly the usual temperatures of molten iron are not sufficiently high to enable the customary deoxidisers to accomplish fully their work. He had in his possession four analyses of cast irons, cupola melted, showing oxygens of 0.039, 0.058, 0.082, and 0.123 per cent., the last being much higher than those usually recorded for iron. The determinations were made by the Ledebur method, reputed to account for only the lower oxides of iron, the carbon di-oxide, and some of the monoxide, by a laboratory in a neighbouring city that is a pioneer in the daily routine analysis of iron and steel for oxygen. All four samples represent a grade of iron having about 2.00 per cent. silicon, 0.65 manganese, 0.60 phosphorus, 0.075 sulphur and 3.50 total carbon.

It is entirely probable that oxygen, in some of its combinations in iron, has a tendency towards increasing the strength by virtue of its influence for higher combined carbon, but the fly in the foundryman's ointment is the fact that, although strong, oxygen-rich irons do not cast well. There exists the anomalous alliance of apparently good iron and bad product. If the presence of oxide in iron were not accompanied by an exasperating sluggishness, due no doubt to a rise in the freezing point, foundrymen would be more inclined to look with favour upon "oxygenated" iron and pronounce its name "blessed."

In regard to Mr. Shaw's shrewd observation as to the frequent lack of harmony between chemical analyses and the physical characteristics of grey iron, it was his opinion that some day all this will be cleared when our analytical chemists acquire the ability to determine readily and accurately the gaseous elements, such as oxygen in all its forms, nitrogen in its several combinations, and perhaps others. Almost daily we have new evidence that these unfamiliar constituents exercise a profound influence upon the physical properties of iron and steel. A veil hangs between the foundryman and the whole truth about his metals, and impatiently he is waiting for the analyst to draw it aside. When that is done there will dawn a new and brighter era for foundry metallurgy as well as for all other metallurgical branches.

A French Criticism.

MONS. E. RONCERAY (Paris) wrote he had no personal data about oxides in cast iron, but Dr. W. H. Hatfield maintains that oxide of iron cannot be present in cast iron at the same time as silicon or manganese.

This opinion seems reasonable, but he did not know if Dr. Hatfield had made special analyses to confirm his opinion.

He ventured to say that, in spite of the presence of such easily oxidised constituents as Si and Mn, it may be that the deoxidation is not quite complete. It is a well-known fact that P and S always remain in small quantities in the dephosphoration and desulphuration processes. What may be the favourable conditions? Even in the American washed iron submitted to drastic purifying treatment there remains 0.015 of S and 0.01 of P. If it is proved that very small amounts of FeO have a good or deleterious influence on strength of cast iron, it may be that there is an interesting point to investigate.

Portevin showed (Association Technique de Fonderie, 1913) that gunmetal cast in a reducing atmosphere showed blowholes which disappeared under the influence of an oxidising agent (lead oxide). Is this a similar action to that mentioned for cast iron? Moldenke has experimented with dissolved oxides in iron, but did not give proofs, so far as he knew. The British Cast Iron Research Association should be able to deal with this interesting problem.

Referring to the film spots which appeared on the ladle, were they not MnS? It seems so from the facts mentioned.

The discrepancy between strength and analysis of iron is probably due to small differences undetected by analysis—for instance, dissolved oxide of iron. The carbon is supposed to exist in two definite forms—combined carbon or carbide of iron and graphite. In fact, as Turner says, there is a continuous series from kish to martensite, and for simplicity he accepts a division in four states: primary graphite, secondary graphite, combined carbon, and missing carbon. This shows how imperfect are the data usually obtained from the laboratory. It was not until micrographical methods had been used that some light was projected on the properties of cast iron, and it may be said that we are far from having a complete knowledge of the question. The treatment of metal before and after pouring amounts to much in its structure, and structure, Keep says, is much more important than chemical composition.

The general opinion is that strength increases with the combined carbon (*vide* Moldenke and many others). Keep maintains the contrary, and he seems to be right. This he had confirmed by his own figures. In this direction also there is much to learn, and this presents another field for exploration.

Referring to tests on cast iron, in his opinion there was nothing good at the present time. He did not know if the Author had knowledge of the memoir of Ch. Frémont (1920) on "Nouvelles Méthodes d'Essais Mécaniques de la Fonte." If not, it will be worth while to study it. M. Frémont's name is certainly not unknown to you, as he was recently awarded the Bessemer Medal by the Iron and Steel Institute. Frémont's methods, which are very ingenious, principally differ from others in that they use very small test-pieces that can be easily cut from castings, so that the properties of the real article can be studied, and not those of a test-bar of possibly the same composition, possibly not, but certainly cooled at a different rate. One test is transverse, and a diagram is taken; but, moreover, Frémont has put forward the taking of small round test-pieces 5.64 mm. dia. (25 mm. sq.), and to shear them in a very small and cheap machine, which also gives a diagram. He maintains that this is equivalent to tensile testing without its drawbacks. In a piece 20 mm. long, taken from a bolt-hole to be drilled in the castings, he can make five tests. These methods are certainly worth while investigating before going any farther in the adoption of international tests. He would certainly put it before the French Foundrymen's Association, as M. Frémont is far too modest to do so, thinking his duty is finished after having devised the process.

He was sorry he could not give as clear and complete a contribution as he would have liked, but the questions raised are very broad, and beyond the scope of one man.

Dr. Stead's Views.

DR. STEAD, F.R.S., wrote: He was glad that you are bringing up the question of whether there is oxide of iron in crude iron, and if there is whether it is prejudicial or otherwise.

Dr. Hatfield's opinion, which you quote, was that generally held by chemists—that oxide could not exist in fluid iron containing silicon and manganese in sensible quantities.

Johnson's statements that all abnormally good irons contained 0.04 to 0.10 per cent. oxygen, while normal charcoal iron contained only 0.015 to 0.025 per cent. were very startling, and led one to consider that a more systematic research was required before definite conclusions could be arrived at. It is more than probable that oxide of iron may be formed when fluid iron is poured from the

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furnace or cupola, and that this attacks the silicon and remains suspended in emulsified form, and, if time is given, will rise to the surface, or, if not, remains suspended in the solid metal just as manganese sulphide behaves.

The analytical method for determining oxygen does not enable one to tell whether the oxygen as oxide is in solid solution or is suspended in a free state or as basic silicate. If it is in separate form it is difficult to conceive that its physical effect can be different from that produced by an equivalent proportion of suspended manganese sulphide or even graphite.

At present one must confess that there has been rather too much assumption and not sufficient actual evidence, and more of the latter is required before one can say what effect minute quantities of oxide have on the properties of cast iron. There is evidence enough that a cold-run casting may contain mechanical inclusions of basic silicates, and be defective in consequence. Johnson's conclusion that an excess of 0.05 per cent. oxygen improves the quality should be regarded as justification for an exhaustive research, and not be accepted unless fully confirmed. It is a research that might be handed over to the newly-established Cast Iron Research Association. In my opinion the most systematic method would be to build up synthetically from the elements, check the results by analysis, and then apply physical tests to the iron produced. The melting could best be effected in a small electric furnace.

Some Sheffield Opinions.

PROF. C. H. DESCH (University of Sheffield) wrote:—The question of the presence of oxygen in cast iron, to which Mr. Shaw draws attention, is a very important one, and is not to be solved without hard work and careful research. It by no means follows that because silicon is present in the molten metal, and silicon reduces iron oxide, oxygen must disappear from the molten mass. All these reactions are of the balanced type, and we do not yet know the equilibrium proportions between the dissolved oxides and non-metallic elements. We know that ferrous oxide exists in molten steel, as the behaviour of that metal in the bath and in casting cannot otherwise be explained. In this connection two facts may be mentioned. The great mass of native iron at Ovifak, in Greenland, has been formed by the reducing action of carbon or of carbonaceous gases on basalt, which contains oxides of iron below the surface of the earth, probably at a considerable depth. This has been a kind of blast furnace reaction in molten volcanic rocks. Benedicks has shown that this iron contains a peculiar structure, an intergrowth of iron carbide and iron oxide. That is, in spite of the presence of carbon, there is much oxide still present. Of course, this may have been formed under great pressure, so that the oxides of carbon could not escape, but the fact is suggestive. Again, Prof. Carpenter and Mr. C. C. Smith* found that when carbon monoxide reacted with pure iron at a comparatively low temperature products which contained iron, carbon and oxygen could be obtained. It is true that silicon was absent, but the Writer sees nothing impossible in the simultaneous presence of carbon, silicon and oxygen in cast iron. Mr. Shaw's own observations point to this conclusion, which would account for some puzzling observations in the foundry. Here he might again call attention to the need for an accurate analytical method for the estimation of oxygen in iron and steel. The published methods are quite unsatisfactory.

He agreed with Mr. Shaw as to the necessity of a standard for tests on cast iron. Almost any results may be obtained by suitably choosing the dimensions and mode of casting of the test bars. A tensile test for such a brittle material as cast iron is not the best form of test, and a standard form of transverse test, with some refinements, would probably best meet the case.

DR. W. H. HATFIELD (Sheffield) wrote: In reply to the Author's conclusions, he could only say that as regards (1) the matter is directly open to experiment. Experiments which he had performed led him to express the views with which the Author is clearly not in agreement. With regard to conclusion (2), there is nothing mysterious about the cases mentioned. Fractures are the result of several influences, the chief of which are composition, casting temperature, and mass. As regards analysis, it is well not to confuse the ordinary simple tests for silicon, sulphur, etc., with complete analysis. With regard to conclusion (3), his answer was Yes! With regard to conclusion (4), he thought it was immaterial whether the transverse test or the tensile test. With regard to conclusion (5), his opinion was that the cast-iron test bar does not represent the casting unless it is cast under the same conditions. Such identical conditions are difficult to attain, but, if testing green sand castings, it is obviously wrong to cast the test-piece in dry sand. His experience had always made him fight a little shy of circular cast test-pieces. He always preferred rectangular or square bars.

MR. JOHN R. HYDE (Sheffield) wrote that the author mentions that Munnock in reply to a statement that in 99 per cent. of cases the composition agrees with analysis is surely a misquotation, as we would naturally expect the composition to agree always with analysis, and he took it that "fracture" was the correct word.

Referring to the various points upon which contributions are invited, his views were as follows:—

Item 1.—The chemical determination of oxygen seems to be surrounded with considerable difficulties, and it would be well for us to decide on a definite standard analysis so that we are all working in the same direction, although, of course, obtaining the same errors, but he felt that it was a matter for expert metallurgists rather than for practical foundrymen.

Item 2.—With regard to the effect of oxide in grey iron. He had made one or two rough experiments which he preferred to discuss at some future date.

Item 3.—It is high time that standard specifications for cast iron, in which experienced men take a hand in the framing, should be standardised in this country.

The transverse test, he found, was more critical than the tensile, and the registration of the deflection before fracture seems to be a reasonable register of the toughness of cast iron.

His experience with the 1¼-in. round bar tested on 12-in. centres is that the small deflection is rather difficult to compare and it might be advisable to adopt 18-in. centres in order to get a finer difference. By all means let us have a circular bar machined from a definite size of casting, for he had already found far more consistent results with the round turned-bar than with the rough cast-bar, and, obviously, turning is much more cheaply done than milling or planing on 2 in. × 1 in. rectangular section.

MR. E. ADAMSON (Sheffield) wrote: Mr. Shaw has raised many interesting problems which are met with in everyday foundry experience, and, instead of discussing the Paper, it will be better to confine criticism to the five questions raised at the end.

1. Mr. Shaw asks: "Can oxygen be found in appreciable quantities in an iron whose chemical analysis would mark it as suitable for making strong grey-iron castings?" In the first place, it is most absurd for anyone to make a statement that oxygen, or any other impurities, *cannot* be found in pig-iron if a certain other oxidisable impurity, or impurities, are present. Unfortunately it is difficult for those accustomed to steel practice reactions to get the graphs of Siemens furnace oxidisation losses out of their minds. One of the elementary lessons taught to metallurgical students is that in Siemens furnace practice silicon is oxidised first, and, therefore, is the most easily oxidisable, and carbon is the last element to be oxidised in the bath; but a long-experienced practical man knows that it cannot be certain that the presence of silicon eliminates oxygen, as it is well known in practical steel-making that, at certain temperatures, carbon is oxidised even before silicon, and over-oxidised steel at times contains silicon and even a fair amount of manganese. The presence of oxygen in either iron or steel appears to be a function of temperature.

On the other hand, neither J. E. Johnson nor W. L. Stork's experiments settle absolutely the question as to whether oxygen has a strengthening

* "Journal of Iron and Steel Inst.," 1918, ii. 139.

influence on cast iron. There is no doubt, from the results of these two investigators, that oxygen can be present in cast- or pig-iron containing nearly 2.00 per cent. of silicon, although the form cannot be determined, but from the fact that the higher percentages of oxygen were found in irons produced at the lower temperatures, before it can be decided whether the influence of oxygen *per se* was the cause of obtaining higher tests. Alongside the increasing percentages of oxygen must be put the structure of the iron due to temperature of manufacture, when it would possibly be found that the strength of the iron was higher in the closer structure

The only conclusion which can be drawn from Johnson and Stork's experiments, the one confirming the other, is that in the presence of oxygen in slightly increasing quantities from the chemical side indicates stronger iron in their series of experiments, but as to whether it is the root cause of greater strength is a matter for further fuller investigation.

2. It is quite true that in certain pig-irons the fracture on re-melting does not conform to what might be expected from the analyses; that is a matter of everyday experience. It is also quite true that large quantities of pig-iron possess such qualities in a lesser degree than others. The question of certain close irons re-melting with an open fracture is an instance of this, and undoubtedly these effects may, to some extent, account for the differences between physical tests and chemical composition, but what will also account for this is:—(a) Differences in fracture due to differences in section. (b) Fractures again are considerably opened up from the fact that it is frequently necessary to retain molten metal in the ladle for considerable periods of time in the case of a big casting. This holding of the metal in the molten condition has the effect of separating out the graphite, opening the grain, and giving a more open structure in the casting.

3. In other countries it has been found that the round test bar gives a better result than the square bar, but, as all the details of these experiments were not disclosed, it is difficult to decide definitely which form of bar is best, and the exact size of the bar must also be considered. On a previous occasion he had suggested that the moment of resistance should be taken as a standard test, as this is based on the size of the bar, including its length and sections. As the test bar in any case does not represent the true strength of the casting, the *shape* of the bar giving the highest test, if cast separately, might be no better than the usual 2 in. by 1 in. or 1 in. by 1 in. if cast on a heavy casting.

4. One of the chief arguments in favour of the transverse bar in showing the quality of the iron is that, whilst the tensile test is a pulling test only, the transverse test includes the tensile test and also gives the deflection, which also indicates the toughness of the iron. In his experience he has had deflections varying from 0.25 in. to 0.80 in. on bars 2 in. by 1 in. by 3 ft. centres, and, strange as it may seem, the latter test of 0.80 in. was on a bar containing silicon 3.00 per cent.

5. With regard to No. 5, this has already been answered in his reply to No. 3.

J. FERDINAND KAYSER (Sheffield) wrote:—Considering the point about the amount of oxygen in iron-carbon alloys, he thought the Author could take it as settled that the addition of a deoxidiser (so-called) does not ever actually remove any gases at all, but acts in such a way that the different gases are not evolved when the metal sets. These remarks apply to all the alloys that he had examined, and the point had been very carefully gone into by Dr. Baker and he (Dr. Baker) came to the same conclusions.

Some Birmingham Views.

PROF. T. TURNER (University of Birmingham) wrote: The questions raised are interesting, but he would not agree with some of the conclusions. To suggest that 50 per cent. of the analyses do not agree with the physical properties of cast iron is grotesque; to say that only 90 per cent. agree is going too far. He would not allow that even 1 per cent. are wrong. If the same material is taken and treated in the same way the same results will be obtained, or Nature's laws are variable. Analyses are usually incomplete, many are incorrect, and all require interpretation. Further, before any conclusions are drawn from the analyses, it is presupposed that the material is uniform in character and that the conditions approach that of equilibrium. One also requires to know not only the ultimate analysis, but also the proximate. In other words, it is not sufficient to know that there is so much carbon and so much sulphur, but whether this sulphur is present as sulphide of iron, sulphide of manganese, or in some other form.

American practice and research has shown the close agreement between analysis and composition. What is true in America is not false here. The apparent failure of chemical analysis in the foundry is, in his opinion, due to three causes:—(1) Imperfect or incomplete analysis. (2) Want of experience in interpretation. (3) Want of attention to accompanying physical conditions, such as size, uniformity, rate of cooling, etc.

He gathered that the Author's contention is that chemical analysis is not by itself the be-all and end-all in reference to the structure and physical character of cast iron. With this he was in cordial agreement. Cast iron is like any other material in that its ultimate properties depend upon two main facts, first its composition, and secondly its method of treatment. We have precisely the same thing in, say, for the sake of example, glass. If cooled very slowly it may devitrify, if cooled quickly it may be very liable to fracture, if carefully cooled it may stand rapid changes of temperature and a good deal of rough usage, and yet the chemical composition is the same. With cast iron we have an added difference in that the chemical composition varies with the method of treatment: carbon, for example, existing as graphite or carbide, and so forth. Further, according to the temperature at which the iron has been made, more or less carbon will be taken up in solution, and with "over-grey" iron it may remain in more or less unstable equilibrium.

He did not undervalue chemical analysis when he said that two materials having the same chemical analysis may possess different properties. Chemical analysis is merely one factor with which we have to deal, though it is, of course, a very important factor. His point was that, provided the chemical composition is the same and the conditions and method of working are the same, the same result will be obtained without variation. If different results are observed with metal of apparently the same composition, we have not to search for an explanation in the locality from which the iron came, or the ore that was used, or the fuel that was employed, or any other such conditions which suggest a kind of hidden or unknown spirit dwelling in the material. What we have to discover is what were the chemical or physical conditions which the particular ore, fuel, or furnace produced. The day has gone by for thinking that a particular brand of iron possesses certain properties. Doubtless it does possess those properties, but when we know what they are and how they are produced, we can reproduce a similar material from other ores, from other fuel, and from other furnaces, though it may not necessarily be best to do so for commercial reasons.

Chemical analyses are only comparable under conditions of equilibrium. In some cases equilibrium is only obtained slowly, and hence it may be possible that merely re-melting in a cupola does not remove completely the physical characters derived from the condition of the blast furnace in which the metal was made.

MR. D. WILKINSON, of Birmingham, wrote:—The retention of oxygen in small quantities by cast iron is not a matter determined solely by the composition of the metal and chemical affinity. Silicon, manganese and carbon have a much greater affinity for oxygen than has iron; but the determining feature will be found in the mass action of the iron, which enables it to hold very tenaciously the last traces of any of the elements usually combined with or dissolved in it.

Half-way through a Bessemer blow about 99 per cent. of the silicon originally present in the charge will be oxidised, while almost the whole of the carbon will still be present. At the end of the blow, when the carbon has been oxidised, the small amount of silicon remaining half-way through the blow will frequently be found quite unchanged, although the oxidation has been continued for

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some minutes and the bath is surcharged with oxide of iron.

Exactly the same thing occurs with the carbon. It can be said that it is impossible to eliminate completely the carbon from cast iron in either the converter, open-hearth, or electric furnace. The carbon content can readily be reduced to about 0.03 or 0.04 per cent., but its further reduction is attended with extreme difficulty.

The mass action of the iron in each case prevents the complete elimination of the element, which is readily oxidised when present in greater amounts. In the case of cast iron oxidised in manufacture or in re-melting, the same action would operate. If, under oxidising conditions, mass action enables iron to retain small amounts of readily oxidised constituents, so it would, under reducing conditions, enable it to retain in combination small amounts of reducible constituents. So that, from the point of view of mass action, there is nothing incompatible in the presence in grey iron containing silicon, manganese and carbon of small amounts of oxygen.

As to its influence being beneficial or otherwise, there is unanimity in the opinion that oxygen in steel is injurious. Analogy would suggest that its presence in cast iron can only be injurious. Quite possibly it may put up the tensile test; but, as remarked in the Paper, it is by no means finally settled that the tensile test accurately measures the quality of a grey iron. A comparison of the tensile tests sometimes obtained on white iron with those obtained on grey iron will show that a high tensile test alone is not always a complete proof of the general strength or quality of cast iron. If the raising of the tensile strength is accompanied by a lowering of deflection, it may mean not a better iron, but a brittle and inferior one.

A Scottish Contribution.

MR. J. ARNOTT, A.I.C., wrote:—With regard to the second heading enumerated by Mr. Shaw, the writer thinks too much stress has been put on the apparent divergence between fracture and analysis, and for two reasons:—

1st. Cases are not so numerous as is frequently stated. The persistence with which these "freak" irons are referred to in some particular quarters seems to suggest that the subject is used as a means to delay the selling of iron to specification. Chemists having control of cast iron in large foundries on being asked whether they had many cases of freaks, invariably state that such irons are few and far between.

2nd. It is generally agreed that it is good practice to use several different brands of pig-iron. Assuming that the brands are all of reasonable quality, as far as analysis is concerned, the special characteristics of any one pig (such as relation of fracture to analysis) has but little influence on the mixed metal.

A Contribution to the Discussion on Mr. Elliott's Paper on "The Basic Hearth Electric Furnace."

In his discussion on the Paper, Mr. Cook gave the following table, which has reference to the tests obtained by Mr. Elliott when converted into the nearest British test.

Heat No.	Arbitration bar, in cwts.	Arbitration bar, in lbs.	Bar, 1 in. sq., 12 in. centres., in cwts.	Bar, 1 in. sq., 12 in. centres., in lbs.
1921.—Cupola ..	25.1	2,812	18.57	2,080
E. F. ..	36.7	4,118	27.16	3,042
1281.—Cupola ..	24.7	2,770	18.28	2,047
E. F. ..	35.5	3,985	26.27	2,942
6271.—Cupola ..	33.4	3,748	24.72	2,769
E. F. ..	45.5	5,096	33.67	3,771
1721.—Cupola ..	31.1	3,002	23.75	2,660
E. F. ..	37.6	4,212	27.82	3,116
8172.—Cupola ..	—	—	—	—
E. F. ..	37.5	4,200	27.75	3,108
8182.—Cupola ..	—	—	—	—
E. F. ..	45.6	5,114	33.74	3,779
3419.—Cupola ..	25.1	2,815	18.57	2,080
E. F. ..	34.1	3,824	25.25	2,828
2221.—Cupola ..	29.5	3,316	21.83	2,445
E. F. ..	35.8	4,022	26.50	2,968
1191.—E. F. only ..	37.0	4,144	27.40	3,069

Moulding Blanks for Change Wheels.

By G. H.

Change wheels of lathes, screw-cutting machines, gear wheels for textile machinery, etc., are always expensive if made in small quantities.

Makers of machinery, such as mentioned above, have a type of pattern quite their own, size of boss, shape of arms, thickness of rim of wheel, all being peculiar to themselves. This all tends to put the foundryman in a quandary when he is asked to make a few change wheels for repairs on a lathe, or the like.

Although there are so many types of wheels for lathes, etc., the all-important factor is the tooth of the wheel. A lathe will work equally as well with an "S" arm as it will with a straight arm, or even a webbed wheel or a disc.

The size of wheels for small lathe might safely be fixed at casting sizes, say 1½-in. to 12-in. wheels, ⅞ in. depth of rim, ¾ in. thickness of rim.

Wheels for medium-size lathes 2 in. to 6 in., plain discs 6 in. to 18 in., with 2-in. boss and arms, depth of rim 1⅛ in., 1¼ in., and 1½ in., thickness of rim ⅞ in. The patterns are made to these measurements for the rim, etc., and by taking a step of ½ in. up or down in size there will then be a range of patterns that will give good results for nearly all ordinary and small lathes, screw cutting and textile machinery. We have never yet met a mechanical engineer who will say he prefers moulded teeth in preference to machine-cut wheels. That being the case, it can readily be seen it is more acceptable to make a plain wheel, and then cut the teeth on a gear-cutting machine providing the gear-cutting machine is in good condition. By this is meant that the spindles run true and the change wheels are all correctly fitting and properly numbered. A boy can then do all that is required, and the wheel will be correct.

To mould such wheels almost any good make of moulding machine will do the work satisactorily, either power ram or hand-ramming machine, and single-sided patterns will answer best, providing, of course, the pattern is fixed to the pattern plate, so that both sides of the mould can be made from the same side. This method saves the time of turning over the pattern plates, and a saving can also be made by having one set of arms for two patterns, the smaller ring pattern of the two to have grooves cut to allow of the arm fitting in. It may even be used for a range of three patterns, but this will have a tendency to make the rim of the smallest of the three a thicker rim, thereby giving extra turning in the machine shop. Great care must always be taken with the pouring of these wheels. The metal must be hot and free from an excess of sulphur, and, more important still, the metal must be skimmed, any dirt going down the runner of the mould immediately jeopardises the casting.

Many of these wheels arrive at almost the finishing stage, sometimes even the last tooth is being cut, when dirt or a blow-hole is found; the wheel is scrapped, and becomes a dead loss, not only to the machine shop, but also to the foundry, as they usually have agreed to replace wasters. Additionally there is the loss of time in machining, which is borne by the buyer. Taking the various sizes mentioned, these wheels could be made in quantities at a very low cost, the chief outlay being the patterns. When once properly made patterns are fixed on the pattern plates, there is hardly a limit as to the number that could be made from the pattern without its deterioration. To say thousands would be no exaggeration. Fortunately there is always a large demand for these wheels.

If one would prefer to use loose patterns a good method is to put the patterns into double-sided plaster odd-sides, which of course is cheaper for small quantities.

Russian Mining and Oil Concessions. — The Soviet Government of Russia is stated to be desirous of granting to foreign enterprise concessions in the naphtha fields at Baku and Grozny, in the coalfields in the Donetz Basin, and the manganese deposits in the Kourak Government. The Germans are reported to have made several offers for the coal concessions, but they have been found unacceptable.

Addenda to "Some Perplexing Foundry Problems."

For the sake of completeness, the Author, Mr. Shaw, is of opinion that the four following extracts should be included.

Mr. Y. A. Dyer, writing on "Some Defects in Foundry Pig Irons" in Vol. 107, No. 17, of the "Iron Age," states:—

Iron oxide is probably directly or indirectly responsible for more foundry ills than any other agency. At times, unfortunately, a foundryman may receive from a furnace company iron which has been badly oxidised by irregularities of furnace practice. In this manner a large percentage of ferrous oxide may be carried through the cupola and temporarily, at least, held in solution with the liquid metal.

These physical and chemical defects which sometimes exist in foundry irons do not appear to the foundryman in a casual reference to the routine chemical analysis and fracture tests—that is, by reference to determinations of carbon, silicon, sulphur, phosphorus, manganese, and noted fractural structure of the metal. These less apparent ills referred to as sometimes existing in pig irons are chargeable to irregular blast furnace operations and control, and when they are not taken account of at the furnace by relegating such irons to the off grade piles are handed down to the foundryman; and in turn their deleterious effects are reflected all down the line of foundry operation.

Irons which contain these very undesirable defects are referred to, unknowingly by many foundrymen, as simply "bad iron." Technically they are chiefly "oxidised" and "leanly carburised" irons, due to furnace irregularities in the form of scaffolds and slips, too heavy burden, excessive limestone, or undue driving of the furnace by reason of desire on the part of the operator to force production, or to certain ill-designed or faulty lines and construction. Scaffolds in the furnace cause serious trouble and detriment to the grade of subsequently tapped pig-iron. When they finally slip a large quantity of iron oxide (the ore not having had time to complete its travel through proper temperatures or zones of dissociation, or decomposition) is precipitated into the hearth of molten metal and is absorbed by and retained in the pig-iron. The result is a product of very inferior quality. Its grading and shipment should be watched closely by furnace operators so as not to be applied on orders calling for first-class iron.

Extract from Technologic Papers of the Bureau of Standards, No. 118.

The conclusions of J. R. Cain and Earl Pettijohn are as follows:—

From our investigations it is evident that the Ledebur method for determining oxygen in steel and iron is subject to many errors not hitherto fully recognised, and that it is very difficult to avoid such errors and to obtain correct determinations by this method. In fact, the precautions required are so great that the method can hardly be regarded as practicable for use as a control method in steel works even if it yielded information of value for control, which is doubtful, as will be shown.

Even when correct Ledebur determinations are made, the only information thus obtained is the content of oxides, existing as such, of iron, manganese (above MnO), and of copper, nickel, and tungsten, if steel ever contains unreduced oxides of the latter three metals, which seems unlikely. The Ledebur method as ordinarily practised gives little or no information about the oxides of carbon present in steel, and there are good reasons for believing that the oxygen so combined is of great importance. There is no connection between Ledebur oxygen determinations and methods of deoxidation. Our own work and Pickard's show that the Ledebur method does not determine any oxygen left as manganous oxide, and it could not therefore determine any residual manganous silicate left in the steel as a result of deoxidation with manganese. The work of Kassel shows that only the ferric iron of iron silicate slags is reduced under the conditions of the Ledebur method. Silicate slags containing ferric oxide are not at all likely to be present in deoxidised steels, the iron in these silicates being present in the ferrous form only. Hence the Ledebur method fails even to determine the oxide of iron present as impurity in steel if there is enough silica present in the bath to combine with it, as is nearly always the case.

From this discussion it appears then that:—(*a*) The Ledebur method requires extraordinary precautions to obtain reliable results. The errors we have described undoubtedly affect in greater or less degree nearly all results by this method that have been described in the literature, and if these are approximately correct it is because of compensating errors; (*b*) the Ledebur method as described herein determines with certainty only oxide of iron, oxides of manganese above MnO, and the oxides of nickel, copper, and tungsten, if the latter three ever exist in steel. In turn, such oxides are determined correctly only in case they exist in the metal uncombined as silicates, which probably seldom happens; (*c*) Ledebur oxygen determinations show no distinguishing features for acid Bessemer, basic or acid open-hearth, duplex, electric furnace, or crucible steels; (*d*) Ledebur oxygen determinations show no difference in steels deoxidised with a variety of deoxidisers.

Extract from Scientific Papers of the Bureau of Standards, No. 350.

The conclusion of J. R. Cain and L. Adler is as follows:—

(1) Graphite does not reduce ferrous oxide or water vapour at 900 deg. if hydrogen is passing at the rate of 2 litres or more per hour.

(2) Combined carbon in iron reduces ferrous oxide (with formation of carbon monoxide) under the conditions given in conclusion 1, to an extent varying with the proportion of carbide present.

(3) The percentage of ferrous oxide reduced by hydrogen from a mixture of iron carbide with ferrous oxide is a function of the rate of passage of the hydrogen, and, as shown by experiment in this Paper, reaches a maximum of 75 per cent. reduction when hydrogen passes at about 3 litres per hour. The remaining oxygen is evolved principally as carbon monoxide and partly as carbon dioxide.

(4) The Ledebur method under most favourable conditions probably cannot account for more than 75 per cent. of the oxygen present in a steel as ferrous oxide.

Extract from the "Iron Age," June 19, 1919.
Oxygen in Cast Iron and Its Application.

The Johnson Theory.—In 1914 the late J. E. Johnson, jun., startled the metallurgists of the world when he published his results on the advantage of oxygen in cast iron. His work is so convincing and so logical, in spite of the common and well-established notions on the subject, that nobody has been able to refute a single argument. Such an eminent authority on iron and steel metallurgy as Prof. H. M. Howe has accepted the work in all its details in his latest book. The work of J. E. Johnson, jun., has revolutionised the metallurgy of cast iron, and it seems apparent that all future work must include an oxygen determination just as we include silicon, sulphur, phosphorus, manganese, and carbon in our every-day analysis.

A summary of the part of this work that applies directly to the contents of this Paper is as follows:—

Iron containing oxygen solidifies at a higher temperature than iron of the same composition containing no oxygen.

Oxygen increases the strength of cast iron.

Iron containing oxygen, if cast in sand, contains somewhat more combined carbon than a similar iron not containing oxygen.

Iron containing oxygen, if cast against a chilling surface, will show a white chill at a higher silicon than a similar iron not containing oxygen, and will show a greater chill for the same silicon as the latter element decreases.

When manganese is added to a metal high in oxygen, some of the latter is removed and the chilling power and strength are thereby reduced.

Steel, when added to cupola mixtures, is oxidised, and it is this oxygen content that gives such mixtures their superior physical properties

XUM

Trade Talk.

THE MAJORITY of the lead mines of Derbyshire are derelict, because it does not pay to work them.

NEW ENGINEERING and brassfounding premises at Corstorphine, Midlothian, which were only opened on the 21st inst., were destroyed by fire the following day.

IT is announced that the Electrolytic Zinc Company of Australia, Limited, has completed a contract with the British Board of Trade for the sale of 750,000 tons of concentrates and slimes.

ONE MAN was killed and eight injured by an explosion which recently occurred in the foundry of Messrs. A. Cohen & Company's metal works, Wild's Rents, a narrow turning off Long Lane, Bermondsey.

AS THE RESULT of a ballot the lead miners at Wanlockhead Lead Mines, Lanarkshire, have decided by large majority to accept the employers' terms. The men have been on strike for over eight months.

THE LYONS TRADE FAIR will be held from October 1 to 15. The Federation of British Industries has secured a stall, and the customary services of displaying catalogues and literature for members and their firms will be rendered.

It is reported that the Norway tinplate works have completed the first rolling of Norwegian tinplate, and that orders from the Norwegian packers have been booked months ahead. It is claimed that the annual production is to be 10,000 tons.

THE MANAGEMENT of Parkgate Iron and Steel Company, Rotherham, state that it is not their intention to close their large works entirely, as announced in several newspapers on Saturday. The works are to be kept open in order to execute orders.

THE SERIOUS EFFECT of the recent strike at Messrs. Gilbertson's steel and tinplate works, Pontardawe, Swansea Valley, has been that the firm had to refuse an urgent order from Japan, which would have found two years' employment to the whole of the mills.

IT WAS ANNOUNCED at Barrow yesterday that Messrs Vickers, Limited, are putting in tenders for the new capital ships for the British Admiralty, including the hulls, engines and guns. Work has improved in the firm's yard as the result of the joiners' strike settlement.

THE PRESIDENT of the Victorian Institute of Engineers states that the engineering profession should be prepared for great industrial expansion in Australia, the advancement and achievements of which must, in the largest part, depend on the work of Australian engineers.

THE DECLARATION recently of the ballot of the West Cumberland iron-ore miners showed that 1,917 voted for acceptance of the masters' terms and 1,150 against, a majority for acceptance of 767. This means an early restart of the mines, which have been closed virtually all the year.

"THE PROGRESS OF THE MOTOR SHIP" was the subject of a paper read last week by Mr. Sydney H. North for Mr. James Richardson (William Beardmore & Sons) at the Oil Conference held in connection with the International Shipping, Engineering and Machinery Exhibition at Olympia.

THE SEPTEMBER REPORT of the Amalgamated Engineering Union again shows a reduction in membership. The total is now 438,844, or 5,136 less than in August. There were 89,290 members unemployed at the beginning of this month, a decrease of 13,572 as compared with the preceding month.

THE AWARD OF THE ARBITRATOR in the Welsh engineers' and founders' wage reductions was made known at Swansea last week. The wages of skilled men are to be reduced at once by 4s. a week, and by a further 3s. as from November 1. The wages of other workers are reduced in a like proportion.

IT IS REPORTED that, included among the orders recently placed for railway locomotives, are contracts given to the Vulcan Foundry, Limited, of Newton-le-Willows, Lancashire, for nine locomotives for the Oudh and Rohilkund Railway, and five metre gauge engines for the Mysore State Railways.

The exports of tinplates and blackplates, the product of Welsh tinplate mills, show for the seven months ending July of this year a reduction of 115,134 tons. Further, a great part of the tinplates exported this year has been from stock, for most of the tinplate mills have been idle for about six months.

IN SEPTEMBER of last year, in Sweden, twenty-five shipbuilding yards were working; now only sixteen are employed to a certain extent. Of twenty-four electrical workshops eighteen are working. The number of workmen employed in the machine industry has consistently diminished by about 1,500 a month.

A COMMUNICATION FROM TOKYO states that a new process by which sand iron or magnetic sand may be converted into pig-iron and thence into steel has just been made public by Goro Matsukata and Dr. Asobu Naito. The discovery, according to the Japanese scientists, will not only revolutionise the steel industry in Japan, but of the world.

COMMERCIAL HOUSES report that German traders, irrespective of existing Australian barriers, are making a keen effort to secure business. Their offers are temptingly low, some quotations being one-fourth of the prices at which British and Australian made goods are now being retailed in Sydney and Melbourne.

EIGHTEEN LANARKSHIRE STEEL MAKERS are appealing in the Scotch Courts against what they declare are excessive valuations of their works, and declare if the proposed valuations are insisted on it will mean the closing down of many works, most of the iron and steel firms in the West of Scotland being involved.

A NEW YORK REPORT states:—In view of the threatened British competition, the leading steel rail manufacturers in the United States have cut prices. Recently rail contracts were closed with Japanese interests on a basis approximately ten dollars a ton below the established list quotation for 47 dollars.

SIR CHARLES PARSONS performed on the 22nd inst. the opening ceremony of the Cleveland Technical Institute, which has been opened in Middlesbrough as a centre for research work, in metallurgical science, and the dissemination of knowledge amongst those engaged in iron and steel production, mining and shipbuilding.

THE STRIKE of over 1,000 boilermakers at Vickers' Naval Construction Works, Barrow, over the employment of one member who was in arrears to his society, and consequently, according to rule, a non-Union member, has been a short one. The men last week decided to return to work, the man having paid up his arrears and been re-admitted to membership.

COMMENTING ON THE LEIPSIC FAIR, which was held from August 27 to September 3, a representative of the Federation of British Industries at Leipsic states that the results of the Fair were generally satisfactory, although a comparatively small attendance of foreign countries was noted. In the metalware industry, business was good, although prices tended to soar.

THE BI-ANNUAL MEETING of the Scottish Divisional Council of the Iron and Steel Confederation met in Glasgow, on September 17. Mr. J. Davidson, Glengarnock, presided, and Mr. A. Pugh, general secretary, was in attendance with the Scottish district officials. A resolution demanding the triennial election of full-time officials was defeated by an overwhelming majority.

MANY OF THE ELECTRIC FURNACES in Sheffield have been idle for a year, and the possibility of their being restarted appeared remote because of the series of advances in the price of current. Recently, however, the Sheffield City Electric Supply Department reduced the price of electricity for furnaces considerably, and as a result it has been deemed expedient to restart some of the furnaces.

ON BEHALF of Messrs. Harland & Wolff, the ship-repairing works of the London Port Authority, with the staff and 1,100 men, have been formally taken over by Viscount Pirrie, who travelled from the North of Scotland specially for the occasion. His lordship was accompanied by Mr. Robert Crighton, the deputy chairman of the firm, who has been appointed managing director responsible for the London undertaking.

AT THEIR SCOTSWOOD locomotive department, Messrs. Armstrong, Whitworth & Company have already completed 350 engines. A large portion of the armour-plate shops at Openshaw have been turned into a repair department, with up-to-date machines capable of repairing 400 locomotives a year, and very many engines for the North-Eastern, the London and North-Western, and other British railways have already been repaired there.

BRITISH MANUFACTURERS are coming to the conclusion that German competition will not prove so formidable as was feared at first, and that the present German trade boom is largely fictitious in character and will fizzle out as did the Japanese boom during war-time. This view is based on reports that although German manufacturers have booked big orders by offering attractive low prices, buyers are finding when goods are delivered that they are of the poorest quality.

COMMENTING ON THE FOUNDATION at Hamburg of a new German-Scandinavian shipping company, the "Christiania Handelstidende" says the Germans are to-day the only nation in the world that can keep their shipping going. The reason for this is the German currency's low exchange, and the facts that German labour is not only cheap but also efficient, that German ships are supplied with cheap bunker coal, and that they are granted numerous privileges in competition with other nations.

THE Dalmellington Iron Company, Limited, report a profit for the year of £38,270. In view of the adverse influences the fact that the net profit is about £17,000 less than it was for 1919-20, is not surprising. The interim distribution on the ordinary in March last was unaltered at 3¾ per cent., but the final is only 3¾ per cent., compared with 6¼ per cent. paid a year ago, making the full distribution 7½ per cent. free of tax, against the 10 per cent., free of tax, paid in the two preceding years.

IRON AND STEEL MARKETS.

Pig-iron.

The position in the pig-iron trade continues without special features or change, a revival of activity being an exceedingly slow proceeding. The effort of the ironmasters to depress the price of raw materials by keeping their plant idle has not yet met with the success which they may have hoped, but they adhere firmly to their resolution not to re-light the furnaces under present conditions, and so far there have been no further developments in the direction of a resumption of the industry. In the Cleveland district two furnaces at the Ayresome Ironworks were re-lighted last week, increasing the number in blast on the North-East Coast to 17, but at least 50 more will need to go in to restore the industry to its full activity. And whilst the furnaces stand idle cheap basic iron is pouring into the Tees in ever-increasing volume to feed the local steelworks. Much of this basic iron has been bought at 87s. 6d. per ton, c.i.f., a price quite unapproachable by British makers. Indeed, 125s. per ton is still named for prompt delivery of No. 3 Cleveland G.M.B., though it can be bought in small quantities for October delivery at 120s. No. 4 foundry is freely offered at 119s. per ton, No. 4 forge and mottled at 117s. 6d., and white iron at 115s. per ton. The decline in prices of fuel is enabling Midland furnace owners to make better offers. It is reported, for instance, that Derbyshire forge has been offered at 125s., and Northamptonshire at 130s. These compare with 100s. delivered for Belgian forge iron, and this latter, of course, is not finding so good a market as it was. It cannot be said that the lower prices for Midland brands mentioned above have brought an appreciable increase in demand. But consumers are beginning to take a greater interest in the market as prices come down to something near a more practicable level.

There is a moderate home demand for East Coast hematite for prompt delivery at 135s. for mixed numbers and 137s. 6d. for No. 1 quality, but there is no forward buying as the view is that prices are likely to fall still further. Mixed numbers are, in fact, offered for export at 130s. per ton, but that is more than Continental buyers are prepared to pay and there is scarcely any foreign business.

Ore.

Business in the foreign ore market remains practically at a standstill, and must continue inactive until furnace plants are again in full swing. Odd cargoes, however, arrive at Tees-side on contract account, but furnace owners are reluctant to entertain fresh dealings while the position continues uncertain. Holders' ideas are firmer, and best Bilbao rubio is now being quoted at not less than about 29s. per ton, ex ship Tees, on the basis of an 8s. freight.

Scrap.

Conditions in the scrap metal markets are generally quiet, but here and there some small increase in buying may be observed, if only in limited quantities for immediate use. In the Cleveland market, for example, steel turnings have realised 40s. per ton delivered, and cast-iron borings have been done at about the same figure. Small parcels of heavy steel scrap have found buyers in the region of 57s. 6d. delivered. Cast iron is idle, with the f.o.r. price no more than about 92s. 6d. per ton. Heavy wrought iron is nominal at approximately 70s. to 80s. per ton.

Finished Iron.

In this section of the market the downward trend of prices is again a noteworthy factor in the position, the most recent development having been a reduction in values of bar iron to the extent of £2, as notified by the Scottish and Lancashire Associations. This brings the selling price down to £14, the initiative in the movement being claimed by the Lancashire Bar Makers' Association, applying only to sales to home consumers. Even with this cut prices for British products compare unfavourably with Continental quotations, Belgian No. 3 bars having been offered recently for delivery in the Black Country at £9 5s. Generally millowners state that at the present rate of demand good unmarked bars cannot be produced for much less than £16. In South Staffordshire area conditions remain about the same as previously reported, but the possibility of resuming work is now approaching nearer from week to week, although as yet it has not been possible to do anything appreciable in crown and commoner qualities bars. More ease in connection with fuel and wages is required before it will be possible to make iron profitably at a price which will enable consumers to buy freely. As things are, they show little or no disposition to do so. For one thing they regard prices as too high, and also they lack confidence, which is not surprising in view of the downward tendency of the market. The considerable reduction in gas strip is reported not to have brought any accession of business. Makers declare the new price unprofitable, but looking at pre-war experience, probably it is still much too high to permit free buying.

Steel.

Reports from the principal centres of the steel industry suggest some slight improvement in the general outlook of the trade, which, if encouraging to a certain extent, is as yet hardly sufficiently pronounced to establish much confidence in a speedy return to more normal conditions. The recent reduction in the prices of some steel products is, however, a step in the right direction, and when finally values react to something like a competitive basis with those of Continental makers, the existing world demand for constructional and manufacturing consumption should provide a ready outlet for works' outputs. In Scotland the cuts made in export steel have not resulted in important contracts. Some foreign willing buyers have not sufficient money to pay for their commitments. Although the sheet mills are running slowly the output is perhaps a little better, as Continental makers are asking more and deliveries are uncertain. At Sheffield the finished steel trades are improving a little. Engineering firms are quiet, with fairly full employment in the electrical branches. Employment is better generally, about 1,000 out-of-works being absorbed each week. Crucible steelmakers are irregularly employed. One firm reports full time, while the rest find half a week too much. Following the lead of the Scottish makers, Midland steel firms have reduced quotations 40s. per ton, bringing angles and joists down to £11 10s. and tees to £12 10s. As the reduction succeeds a very recent drop to almost a similar extent, it has caused some surprise.

Metals.

Copper.—A rather easier tendency has been marked in the market for standard copper, the absence of consumptive buying influencing lower levels, but with fluctuations only fractional in range. Considerable quantities of scrap metal are still available, and this to a certain extent hampers the demand for virgin copper. An interesting feature of the position is the rapid industrial recovery of Germany, as out of 21,000 tons of copper exported from the United States in July, 10,600 tons went to Germany, while only 700 tons were taken by the United Kingdom. Closing prices:—Cash: Wednesday, £67 12s. 6d.; Thursday, £67 12s. 6d.; Friday, £67 15s.; Monday, £68; Tuesday, £68. Three Months: Wednesday, £68 10s.; Thursday, £68 10s.; Friday, £68 10s.; Monday, £68 15s.; Tuesday, £68 15s.

We understand that the directors of the Arizona Copper Company, Limited, have practically concluded an agreement with an important corporation in the United States with which they have been negotiating for a fusion of interests for a considerable time past. The fusion will take the form of the acquisition of shares of the American corporation by the Arizona Copper Company, which will then become merely a holding concern. The terms of the proposed agreement will be communicated to the shareholders within the next few days.

Tin.—Movements in values for standard tin have indicated a slight but steady improvement, but until a more active consumption is in evidence, occasional downward fluctuations must be expected. In the States, however, consumers are taking a more active interest in the market, while the revival of the Welsh tinplate industry is a further encouraging factor in the situation. Large reserves are being held in the Malay States, but seeing that they were acquired at something like £220 per ton, an appreciable rise will be necessary before these stocks are realisable at a profit. Closing prices:—Cash: Wednesday, £156; Thursday, £156 2s. 6d.; Friday, £156 5s.; Monday, £157 10s.; Tuesday, £157 2s. 6d. Three Months: Wednesday, £158; Thursday, £158 2s. 6d.; Friday, £158 5s.; Monday, £159 15s.; Tuesday, £159 5s.

Spelter.—The fluctuations of the foreign exchanges have imparted fresh interest into the position of this metal. The galvanising trade in this country continues to show signs of recuperation, and inquiries from all parts are becoming more and more in evidence. Closing prices:—Wednesday, £25 5s.; Thursday, £25 5s.; Friday, £25 10s.; Monday, £25 15s.; Tuesday, £26.

Lead.—Values have shown little change. Demand from home consumers has slackened. Reports from Germany show that domestic consumption is taking all available supplies from that quarter, and it appears that fair quantities are being imported. English closing prices:—Wednesday, £24; Thursday, £23 15s.; Friday, £23 15s.; Monday, £24 5s.; Tuesday, £24 5s.

XUM

Gazette.

MESSRS. H. MCCULLOCK and H. NEWITT, electrical and general engineers, 44, New Park Street, Leeds, trading under the style of McCullock & Newitt, have dissolved partnership.

MESSRS J. R. BADGER and W. PARKINSON, engineers, Garden Street, Padiham, trading under the style of The B.P. Engineering Company, have dissolved partnership.

THE SHAREHOLDERS of the Mons Engineering Company, Limited, have decided that the company be wound up voluntarily. Mr. C. Latham, 15, Eastcheap, E.C.3, has been appointed liquidator.

THE LAST DAY for receiving proofs in connection with a dividend to preferential creditors to be paid by the Metallic Waste (Parent) Syndicate, Limited, 10 and 11, Jermyn Street, London, S.W., is October 3.

MR. J. L HAYWOOD, residing at 55, Darby Street, Blackheath, Rowley Regis, and carrying on business as Jesse Haywood & Son, at Marlow Street, Blackheath, nut and bolt manufacturer, has been adjudicated bankrupt.

TRADING in the style of Milgrom & Taylor, Messrs. J. Milgrom, J. Milgrom, and D. R. Taylor, 329, Lillie Road, Fulham, sheet metal works, have dissolved partnership, as from September 8. Debts by J. Milgrom and D. R. Taylor.

MACHINERY AND STEELS, LIMITED.—At a meeting held on August 3, it was resolved:—That Mr. E. H. Hawkins, 4, Charterhouse Square, E.C., be appointed a liquidator of the company to act jointly with Mr. C. H. Bull, 6a, Devonshire Square, E.C.

BLACKHALL ENGINEERING COMPANY, LIMITED (in liquidation). A note having been presented to the Lords of Council and Session by Jas. Winning, 93, West George Street, Glasgow, C.A. liquidator, an interlocutor has been pronounced, dated September 12, 1921, allowing answers within eight days after intimation. Claims to liquidator by January 9.

CITY ELECTRIC WELDING COMPANY (NEWCASTLE), LIMITED.—It was resolved August 30, confirmed September 14:—That the company be wound up voluntarily. Mr. J. C. Graham, jun., 16a, Grainger Street, Newcastle-on-Tyne, accountant, was appointed liquidator. Meeting of creditors at liquidator's October 4, at 11. Claims to liquidator by October 14.

Publications Received.

MESSRS. R. B. HODGSON & COMPANY (SHEFFIELD), LIMITED, Sentinel Steel Works, Sheffield. "Pinnacle Steels."

MR. A. M. GORE, 105, Dryburgh Avenue, Burnside, Rutherglen. "The Non-Drift Louvre," for Steel or Timber Ventilators.

MESSRS J. H SANKEY & SON, LTD.; Essex Wharf, Canning Town, E.16. "Pyruma," the Fire Cement with 101 uses.

MESSRS. METROPOLITAN VICKERS ELECTRICAL COMPANY, LIMITED, 4, Central Buildings, Westminster, S.W.1. "Waterwheel Alternators."

MESSRS. KYRN & LAHY METAL WORKS, LIMITED, steel founders and engineers, Letchworth, Herts. "Steel Castings and General Engineering Work."

WE HAVE RECEIVED from the Development Committee of the Cardiff City Council a handsomely printed and illustrated copy of a brochure they are issuing under the title of "Cardiff, the City of Golden Opportunities for the Manufacturer," embodying a survey of its commercial advantages and suitability for the establishment of works, factories, etc.

Tests of a High-Speed Grinding Attachment.—One of the British tool-making firms has been constructing grinding heads for small internal grinding, in which the grinding spindle is required to revolve at about 45,000 r.p.m. One of these grinding attachments has been tested in the National Physical Laboratory in order to show that this speed is really obtained. The drive is by means of a stretched rubber band and at speeds about 20,000 to 30,000 r.p.m. it shows negative slip; that is, the grinding spindle runs faster than the speed given by the ratio between the diameters of the pulley wheels and the speed of the driving spindle. The spindle ran quite satisfactorily at 45,000 r.p.m., and even at this speed showed a slip of but one-sixth per cent. The makers have expressed a wish for a test upon a similar spindle running at 100,000 r.p.m., and this will probably be undertaken as soon as a suitable method of measuring the speed has been devised.

Company News.

Sir Wm. Arrol & Company, Limited. — Half-yearly dividend, 3½ per cent. actual on cumulative preference.

Thos. W. Ward, Limited.—Ordinary dividend, 5 per cent., tax free, making 10 per cent., tax free, for year.

Drop Forgings, Limited. — Capital £5,000 in £1 shares. Directors: M. Reid, J. A. Reid, and J. B. Gardner. Registered office: 156, St. Vincent Street, Glasgow.

Victoria Bridge Engineering Works, Limited. — Capital £10,000 in £1 shares. Directors: I. Robson, R. Livingston, J. Wright, and J. E. Rutherford. Secretary: J. Wright.

R. A. Skelton & Company, Steel and Engineering, Limited.—Capital £30,000 in £1 shares (20,000 preference, 5,000 "A" ordinary, and 5,000 "B" ordinary). Registered office: Moorgate Station Chambers, E.C.

Staveley Coal & Iron Company, Limited. — Profit, £232,740; brought forward, £46,424; final dividend, 1s. 3d. per share on fully-paid, and 11¼d. per share on partly-paid, making 10 per cent., free of tax; carry forward, £47,277.

William Ogilvie, Limited.—Capital £5,000 in 4,000 cumulative preference shares of £1 each, and 4,000 ordinary shares of 5s. each, to acquire the business of an engineer and ship-repairer carried on by W. Ogilvie, at Methil. Directors: W. A. Ogilvie and R. Allan. Registered office: 53, East High Street, Methil.

Sheepbridge Coal & Iron Company, Limited.—Net profit, £109,138; brought forward, £33,561; less interim dividend paid, £33,463; balance for disposal, £109,236; final dividend, 5 per cent., making 7½ per cent. for year, free of tax, ordinary shares at 1s. each, £58,557; preference, at 1s. each, £5,613; part-paid preference at 4.8d. each, £2,754; carried forward, £42,310.

C. & H. Crichton (1921), Limited.—Capital £75,000 in £1 shares, to take over the undertaking of C. & H. Crichton, Limited (incorporated in 1903), and to carry on the business of general engineers, shipbuilders, etc. The shares to be allotted to Sir John Ellerman, Bt., are Nos. 1 to 30,000, of which 1 to 29,000 are to be known as the Ellerman shares, and are to be transferable to Ellerman Lines. Directors: J. Crichton, H. H. McAllester (Ellerman director), C. J. W. Crichton, and H. E. Henderson. Registered office: Tower Buildings, Water Street, Liverpool.

Personal.

LT.-COLONEL F. I. LESLIE DITMAS has returned to this country, and is now stopping at Baronsmead, Fleet, Hants.

THE LATE MR. W. H. LE MESURIER, civil engineer, for nearly 45 years associated with the Mersey Docks and Harbour Board, left £14,276.

MR. A. CROSSLEY, chief works manager to Clayton Wagons, Limited, and Mr. J. Clements, London manager, have been appointed associate local directors of the company.

THE LATE MR. C. H. EDEN, managing director of Vivian & Sons, Limited, Hafod Copper Works, Swansea, left estate of the gross value of £20,921, the net personalty being £15,730.

MR. G. W. GRAY has resigned his position as assistant manager and chief mining engineer of the Rio Tinto Mines in Spain, and has entered into partnership with Mr. W. Selkirk, consulting mining engineer, 4, Broad Street Place, E.C.2.

MR. ARTHUR BALFOUR, Mr. P. MacGregor, Mr. S. Robinson, and other promient Sheffield steelmakers who have been visiting Washington, have now arrived in Canada, where they are discussing tariff matters with Sir George Foster, Minister of Trade and Commerce.

MR. A. T. COCKING, late a managing director of Kynoch, Limited, and who has had a life-long experience of the chemical trade, has been elected technical director of the Staveley Coal & Iron Company, Limited. Mr. Berresford, who has been associated with the company for fifty-seven years, has also been elected a director.

The
ELLISON CATALOGUE
of Electric Control Gear.
gives full particulars, capacities, dimensions and prices of ELLISON CONTROL GEAR. Please ask for List No. 100.
GEORGE ELLISON, PERRY BARR, BIRMINGHAM.